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Notified in A.C.Is. for the week ending 8th February, 1939.

26
Manuals
1799



**Small Arms Training
Volume I, Pamphlet No. 7**

**.303-inch Machine Gun
Part III.—Fire Control**

1939

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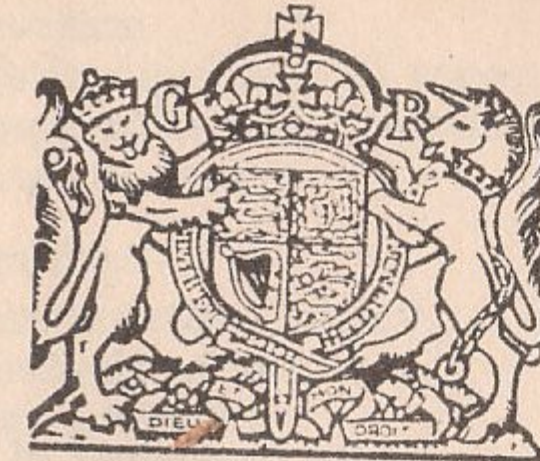
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By Command of the Army Council,

H. J. Creedy

THE WAR OFFICE,
8th February, 1939.

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Territorial Army units will receive the same distribution as regular units.

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GENERAL

Small Arms Training, Vol. I, Pamphlet No. 7, Part III, deals with the various methods of applying machine gun fire. It is written for officers and N.C.Os. whose duty it will be to direct and control fire, but before studying it they should be thoroughly conversant with Small Arms Training, Vol. I, Pamphlets No. 1, Sec. 2 (Theory of Small Arms Fire) and No. 2 (Application of Fire). A very elementary knowledge of mathematics will assist the reader in grasping the methods of fire control quickly.

DEFINITIONS

(See also S.A.T., Vol. I, Pamphlet No. 7, Part II)

Angle of distribution.—The angle between adjacent lines of fire opened up to divide a target wider than the gun-frontage into equal parts, the flank guns being laid on the flanks of the target.

Angle of sight.—The angle contained between the line of sight and the horizontal plane. The angle is said to be positive (+) when the target is above the horizontal plane through the gun position (Fig. 4) and negative (−) when the target is below it (Fig. 5).

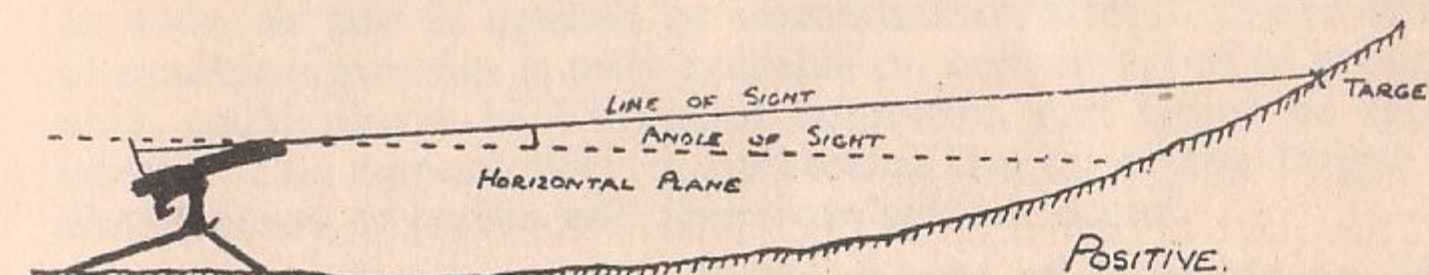


Fig. 4.

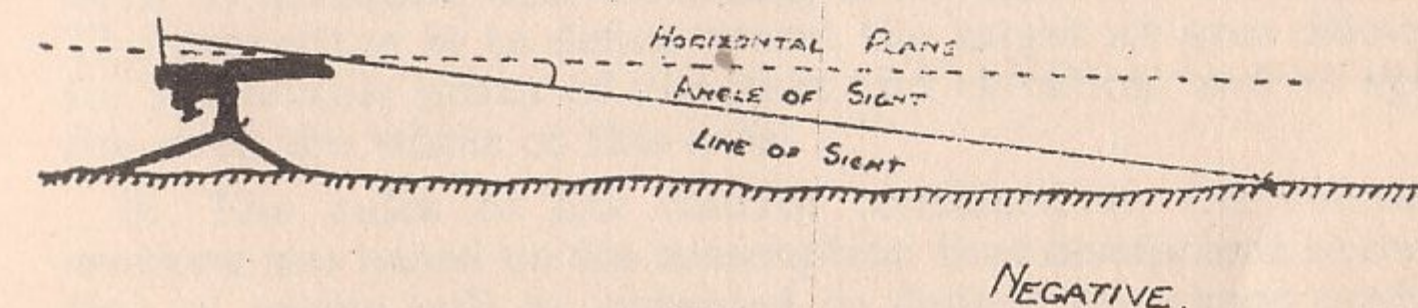


Fig. 5.

Distribution.—The opening out of parallel lines of fire.

Flanking fire.—Fire applied from a flank across the front of a locality occupied by our own troops, or, if they are advancing, at an angle to their line of advance.

Fixed line.—A term denoting that measures have been taken for maintaining elevation and direction in darkness, smoke, etc., so that fire will fall on a pre-arranged area of ground.

Line of fire.—The direction of the target from the gun.

Minimum clearance.—A term used to denote the minimum height of the centre bullet of the cone above the heads of our own troops for the latter to be safe.

Overhead fire.—Fire passing over the heads of our own troops.

Quadrant angle.—The angle which the axis of the barrel makes with the horizontal plane.

Safety angle for flanking fire.—The minimum lateral angle by which a line of fire must clear our own troops in order to ensure their safety.

Safety angle for overhead fire.—The minimum angle which must be included between the axis of the barrel and the line of sight to our own troops in order to ensure their safety under overhead fire.

Tangent angle.—The angle which the axis of the barrel makes with the line of sight.

SECTION 23.—GENERAL PRINCIPLES

1. Introduction.—The considerations which govern the method of applying machine gun fire are :—

- i. The best fire effect on the whole target.
- ii. Economy of time and ammunition.
- iii. Simplicity and speed.
- iv. Safety of our own troops.

The factor of surprise as applied to fire cannot be over-estimated.

Fire control orders must be framed in such a way that all these requirements are met.

The system of fire control laid down in this pamphlet is worked out on the above basis and should be adhered to. Occasionally the situation may not permit the rules given to be carried out in their entirety. Common sense, and a knowledge of how the rules are arrived at will enable the best fire effect to be obtained in these circumstances.

2. Basis of fire control rules.—i. Fire effect is desirable as soon as fire is opened or immediately after. Observation of machine gun fire is only possible on certain types of ground, and, particularly in European countries, can never be relied upon. The opportunity of correcting fire on to the target by observation of strike will therefore seldom occur.

ii. There is no quick reliable means of determining with precise accuracy the effect of climatic conditions. Errors, both of direction and elevation, must therefore be expected. The procedure is to define round the target an area allowing for reasonable errors of direction and elevation, and to apply fire over the whole of this area.

iii. The rules of fire control contained in the following sections are based on the assumption that insufficient observation of strike will be obtained to deduce the exact position of the beaten zones. Every endeavour, however, must be made to pick up strike of the bullets and to correct fire.

3. Direct and indirect fire.—i. The normal method of engaging a target will be by direct fire, *i.e.* by laying on the

target over the sights. The main asset of direct fire is its extreme flexibility, which enables a succession of targets over a wide arc to be engaged with facility.

The technical disadvantages of direct fire are the personal errors of Nos. 1, in laying, the difficulties of indicating and recognizing the target, and the possible obscuration of the field of view.

ii. The machine gun is capable of firing indirect, *i.e.* the gun is laid on an auxiliary aiming mark, with the elevation required to hit the target, obtained and placed on the gun by instruments. Indirect fire is employed when it is impossible or inadvisable to occupy a direct fire position.

The main technical advantage of indirect fire is that the necessity for indicating the target to a number of individuals is removed. The laying of the gun is mechanical, and its accuracy is not affected by light or distance.

The disadvantages are the necessity for additional measurements and calculations, and the difficulties of crest clearance owing to the flat trajectory.

iii. Conditions which obstruct the field of view (*e.g.* bad visibility, fog, smoke screens, etc.) often arise after a position is occupied. Consequently, when direct fire is to be employed, certain arrangements as for indirect fire, should be made as soon as time permits. The details of these arrangements can be found in Section drill—Direct fire (Sec. 17).

iv. The principles and details of fire control set down in this pamphlet apply both to direct and indirect fire. As the methods of fire, and details of fire discipline, are in many cases not the same, direct and indirect fire are treated separately in the remainder of this part.

SAFETY PRECAUTIONS

On all occasions when the gun and dummy cartridges are used for instructional purposes, the instructor will carry out the following safety precautions :—

- i. Inspect all locks to ensure that the striker does not protrude through the firing pin hole.
- ii. Inspect all ammunition to ensure that all cartridges are dummies.

Note.—When instruction is being given in mechanical subjects, D.P. stores if available will always be used.

LESSON 95.—ELEVATION

Instructor's Notes

Stores :—

Gun and tripod, dial sight, range table, blackboard.

First ensure that the class understand the forces which act upon the bullet (S.A.T., Vol. I, Pamphlet No. 1, Sec. 2).

Explain the tangent angle and demonstrate how it is applied to the gun by the tangent sight—show how whenever the gun is laid (direct or indirect) the two components of elevation are the tangent angle and the angle of sight.

Demonstrate elevation as applied to the gun with the dial sight (indirect fire) and finally explain the quadrant angle.

1. When firing direct, elevation is given to the machine gun by setting the tangent sight at the graduation corresponding to the range to the target and directing the line of sight on to

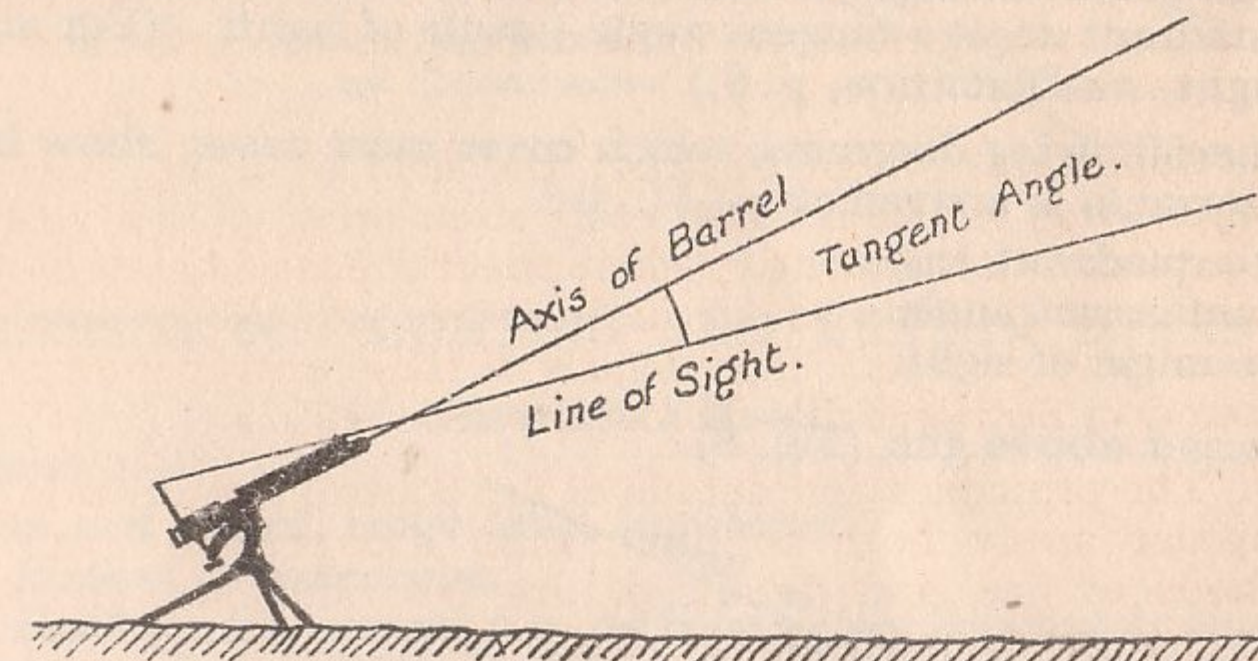


Fig. 6.

the point of aim. This process sets the axis of the barrel at an angle above the line of sight (Fig. 6). This is the angle of tangent elevation (tangent angle) for the range at which the tangent sight is set.* Tangent angles for all ranges have been determined and are laid down in the Range Table.

2. When firing indirect elevation or depression is placed on the gun by means of the dial sight in two components :—

- i. The range (tangent angle) on the range drum.
- ii. The angle of sight to the target on the angle of sight drum.

It may sometimes, however, be convenient to the fire controller to be able to express the angle of elevation given

* Except where the line of sight is abnormally steep, *i.e.* in mountainous countries. This is explained in Lesson 96.

to a gun in relation to the horizontal. This angle is known as the quadrant angle, and is the angle between the axis of the barrel and the horizontal (Fig. 7).

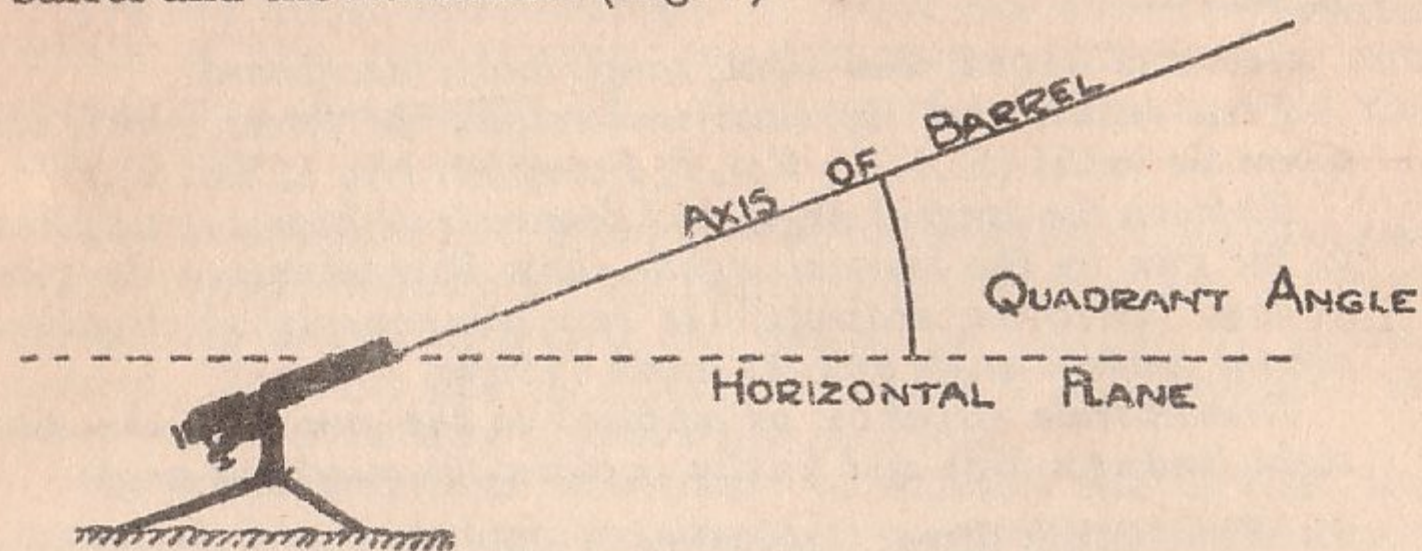


Fig. 7.

The quadrant angle is calculated from the formula :—
 Quadrant angle = tangent angle \pm angle of sight. (For angle of sight, see Definition, p. 5.)

The following diagrams, which cover most cases, show how the formula is arrived at :—

Q = quadrant angle.

T = tangent angle.

S = angle of sight.

Target above gun (Fig. 8).

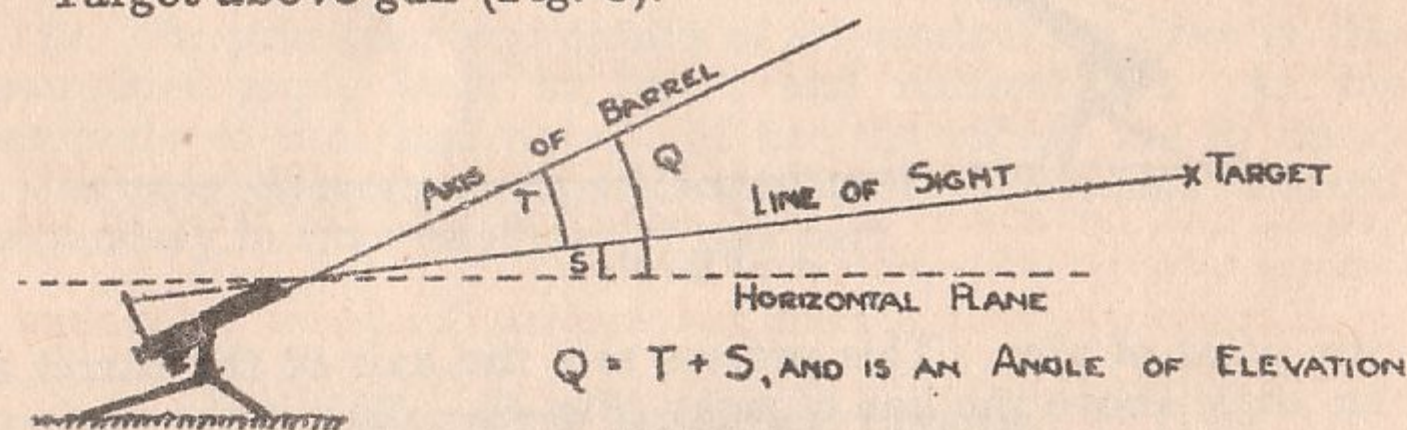


Fig. 8.

Target level with gun (Fig. 9).

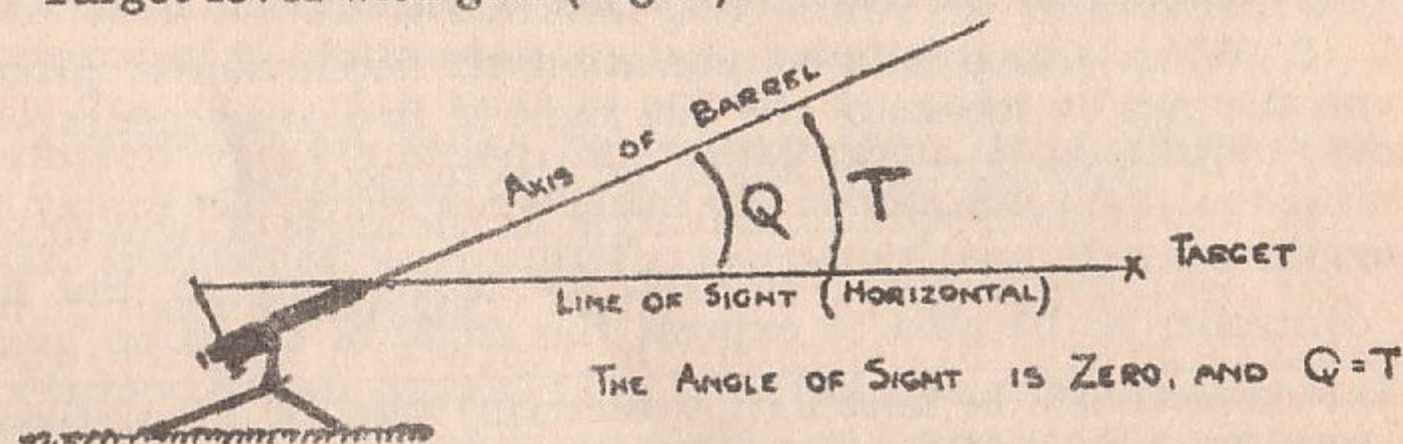


Fig. 9.

Target below gun (Fig. 10).

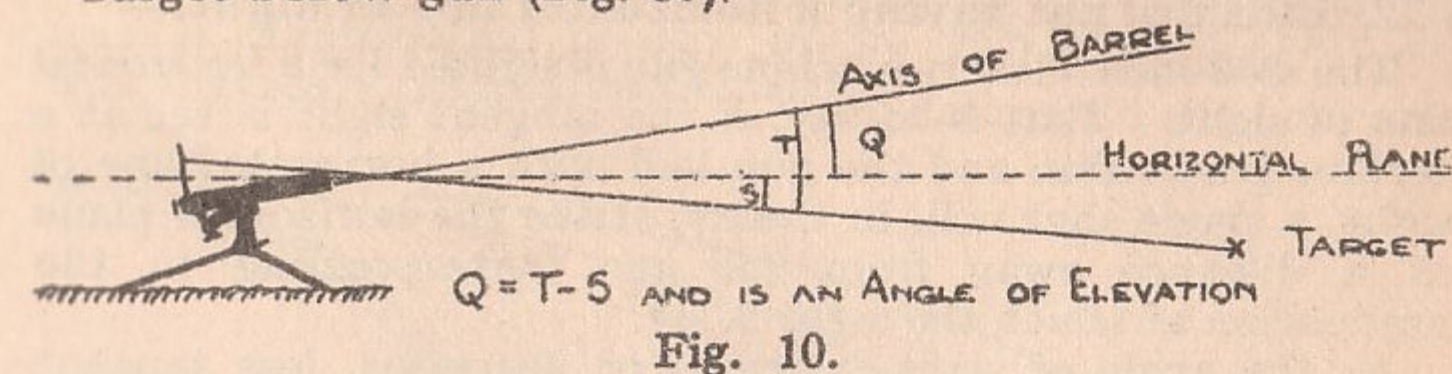


Fig. 10.

Target far below gun (Fig. 11).

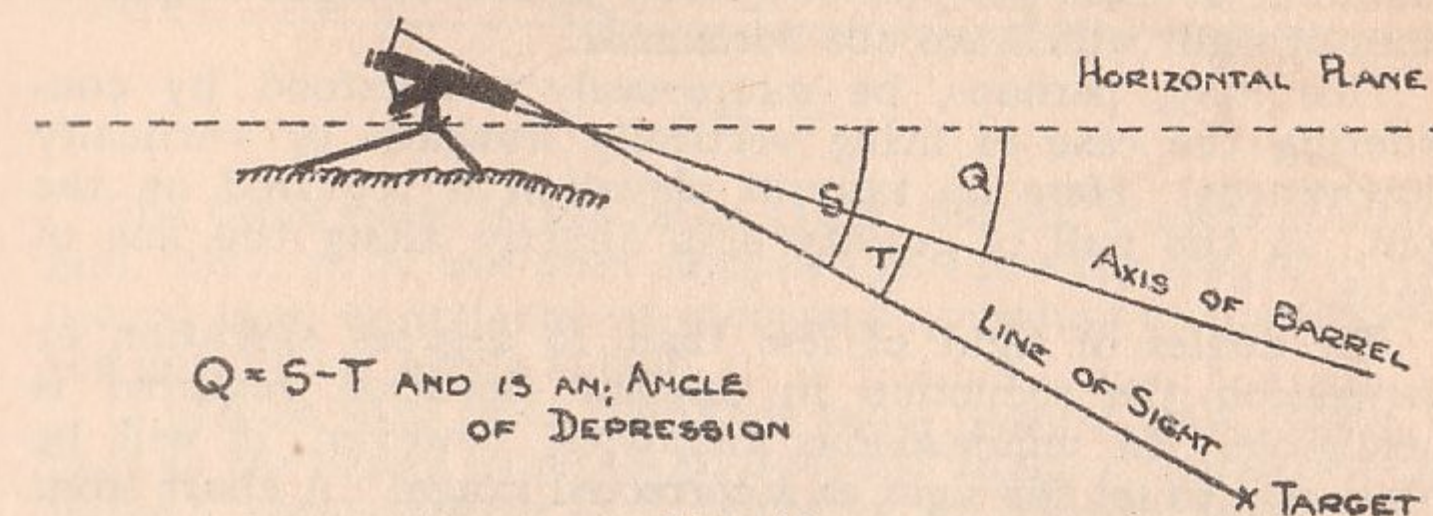


Fig. 11.

LESSON 96.—SIGHTING AND BEATEN ZONES

Instructor's Notes

Stores :—

Gun and tripod, range table, blackboard.

Method of instruction.

Explain the normal (i.e. approximately horizontal) line of sight, and the abnormal in conjunction with the chart in the range table (p. 16) and para. 2 below.

Explain the beaten zone and how it is affected by ground (range table, p. 7).

EXPLANATION

1. Sighting of machine guns.—

In common with other small arms, a mean graduation for each range has been adopted, and guns are carefully tested for accuracy before issue. In course of time wear to mountings and barrels, and irregularities in packing, may require individual gun corrections to be made when setting the tangent sight for a particular range.

On all occasions when the gun is firing ball ammunition and it is possible to determine the range with accuracy, the gun range should be noted, if possible corrected for the atmospheric conditions of the day, and recorded.

2. Effect of not having a horizontal line of sight.—

The .303-inch Vickers machine gun is sighted for a horizontal line of sight. That is to say, if the tangent sight is set at a certain graduation and the gun laid with a horizontal line of sight, a single shot will, in theory, strike the horizontal plane at a distance away from the gun corresponding to the graduation at which the sight is set.

As the angle of sight increases or decreases, less tangent elevation is required to cause the bullet to travel the same distance, because the pull of gravity is not at right angles to lines of sight which are not horizontal.

This may, perhaps, be more easily understood by considering the case of firing vertically upwards or vertically downwards. Here no tangent elevation is required on the gun, as the pull of gravity acts directly along the line of sight.

For angles of sight of less than 10 degrees elevation or depression the reduction in tangent elevation required is negligible. In mountainous countries, however, it will be necessary to set the sight at a corrected range. A chart from which the corrected range for abnormal angles of sight can be obtained is given in the range table (p. 16).

3. Beaten zones.—

The beaten zone of the machine gun has similar characteristics to that obtained in collective rifle fire. The fixed mounting gives greater accuracy and closer grouping. The dimensions of the beaten zones for various ranges have been obtained by experiment, and are laid down in the range table. The rules contained in this pamphlet are based on these dimensions, which vary little for different guns and mountings, and hence can be taken as constant for each range.

As in collective rifle fire, the length of the beaten zone decreases as the range increases. Beyond 2,000 yards the machine gun beaten zone again begins to increase. This is due to minor differences in the velocity of individual bullets.

Its breadth increases up to extreme range.

The fact that it is very narrow in comparison to its length calls for great accuracy in direction, and renders the gun peculiarly suited to engage from a flank targets with width and little depth.

If, however, the target has depth it may be advisable to engage it by frontal fire, so that the length of the beaten zone may be employed to cover the depth of the target as opposed to its width.

The effect of ground on the beaten zone of the machine gun is in general as shown in Pamphlet No. 1 for the rifle.

In addition, it should be remembered that plunging fire from a commanding position on to level ground (Fig. 12) will produce a reduced beaten zone.

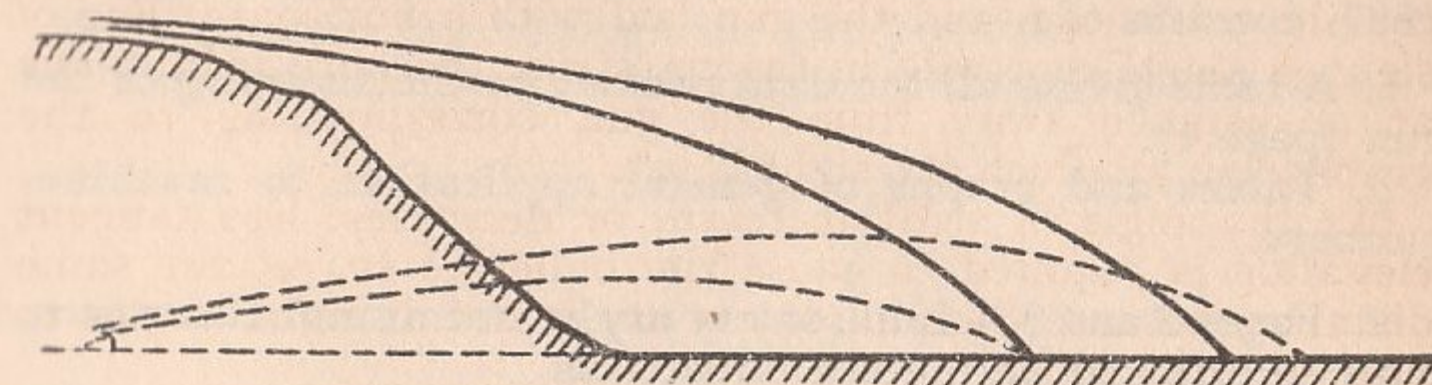


Fig. 12.

The table given in the range table, .303-in. Vickers machine gun, 1937, p. 7, has been compiled to show the length of the beaten zone as reduced or increased according to the slope of the ground on which it falls.

It will be seen from the range table (page 1, cols. 3 and 4) that as the range increases so does the angle of descent of the bullet; consequently each bullet in its descent endangers a smaller area of ground at long ranges than at short ranges.

For this reason, and because the beaten zone widens as the range increases, longer bursts must be fired to fill the beaten zone.

The following *lengths of bursts* are laid down as a guide, and should be known to all firers:—

Yards						Rounds
Up to 1,100	..	..	..	..	..	10-20
1,100-1,500	..	..	..	..	..	20-30
Over 1,500	..	..	..	..	..	30-50

LESSON 97.—RANGE TABLE AND CLIMATIC INFLUENCES

Instructor's Notes

Stores:—

Range table, blackboard.

Method of instruction.

Each page of the table should be explained and understood before passing on to the next. The table and scale referred to in paras. 2 and 5, below, should not be explained at this stage.

The class should be given simple exercises in all the other tables and scales until they are thoroughly familiar with their use.

EXPLANATION

1. The Range Table of the .303-in. Vickers Machine Gun, 1937, consists of :—

- i. A table giving all the data relative to the shooting of the gun (page 1).
- ii. Tables and graphs of general application to machine-gunnery.

2. Pages 2 and 3.—Lifts, safety angles, minimum clearances, temperature and barometer corrections.

This table contains all information which will normally be required in the preparations for engaging a target, viz :—

- i. The tangent angles for all ranges (100 and 50).
- ii. The safety angles and minimum clearances for all ranges to our own troops.
(To assist in working out overhead problems.)
- iii. The angular amount by which each elevation has to be increased so as to add 100 yards on to the range ("lift").
- iv. The allowances to be made for variations in temperature and barometer (see para. 10, below).

3. Pages 4–6.—Wind allowances.

4. Page 7.—Influence of ground on beaten zones.

5. Pages 9–11.—A table for converting oblique to true bases. (Instructions for use on page 8.)

6. Pages 12–13.—A.V.I. table. (Instructions for use on page 8).

The uses of the V.I. table are varied, the most important being :—

- i. To determine, knowing the range, the distance or height subtended by a certain angle.
- ii. To determine, knowing the range, the angle subtended by a certain distance or height.

In Fig. 13, if G is the gun and GA the range, then AB is the distance subtended by AGB at the range GA, and A_1B_1 is the distance subtended by AGB at the range GA_1 .

Similarly, the angle AGB is said to subtend AB and A_1B_1 at the ranges GA and GA_1 respectively.

7. Page 14.—A formula for determining angle of sight and allowance for moving targets.

8. Page 15.—Graph for calculating quadrant elevation and clearances. (The Q.A. graph.)

This graph is formed by plotting to scale the path of the centre bullet for quadrant angles, increasing by 10' increments, from depression 3° to elevation 10° 10'.

The thick, black horizontal line marked "O" represents the horizontal line through the gun position.

The vertical lines give the ranges, which are shown on scales

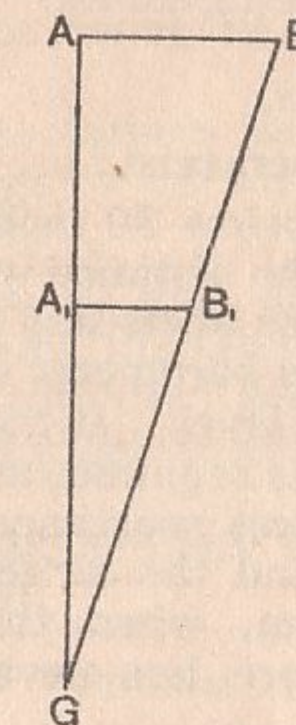


Fig. 13.

at the top and bottom of the graph, and the horizontal lines give heights above and below the gun position in metres, as shown on the left-hand side of the graph. As the heights used are not always in metres, a corresponding scale of yards is given on the right-hand side of the graph.

The chief use of the graph is to determine the Q.A. for targets at any height above or below the gun.

For example :—

Range to target 1,650 yards (lower elevation 1600 yards).

Height of target above gun 35 yards.

Plot the target on the graph, *i.e.* run up the vertical line through 1,600 on the bottom range scale, to a point directly level with 35 yards on the right-hand scale. (Above the thick, black, horizontal line.)

Note the curve which passes through this point, viz :—El. 3° 50'.

This is the Q.A. required.

The graph is also used in connection with crest clearance and the safety of our own troops, and at the top and bottom gives information relative to the calculations of these. The use of the graph in this connection is dealt with under the various sections concerned.

9. Page 16.—Chart for firing up or down hill.

10. Climatic influences.—

i. The following are the normal conditions for the sighting of small arms :—

Barometric pressure. 30 inches. (Mean sea level.)

Temperature. 60 deg. Fahrenheit.

Still air.

A horizontal line of sight.

ii. Barometer and temperature.

If the barometer falls below 30 inches, less elevation than is normally required for the distance will be necessary, as the atmosphere being less dense offers less resistance to the bullet. It should be noted that the barometer will fall 1 inch for every 1,000 feet above mean sea level. If the barometer rises above 30 inches, more elevation is required, as the air is denser.

The bullet meets with less resistance in hot weather, when the temperature is high and the air less dense; and greater resistance in cold weather, when the temperature is low. In the former case, therefore, less elevation is required and in the latter more.

Allowances for barometer and temperature variations are normally small, and are not usually necessary except at great heights or under conditions of extreme heat or cold.

Allowances for 1 inch rise or fall of barometer and 10° rise or fall in temperature will be found opposite each range in Cols. 7 and 8 of pages 2 and 3 of the range table. It should be noted that for a *fall* in barometer, and a *rise* in temperature the allowance to be made is subtracted and vice versa.

iii. Wind.

Winds blowing directly along the line of fire from front to rear will affect the elevation, but here again unless the wind is very strong and the range long, the allowance required is small.

Winds blowing directly at right angles to the line of fire will affect direction, and have considerable effect on the bullet, particularly at long ranges.

Winds blowing from a direction oblique to the line of fire will affect both direction and elevation.

Although where speed is essential it may be necessary to estimate in taps the lateral allowance to be made for a side wind, recourse should be had to the graph in the range table, when time permits.

On page 4 of the range table is given a table showing the effect of wind of various strengths on flags, which may be of assistance in estimating the speed of the wind.

Having obtained this estimation, the allowances required may be obtained from the table on page 6.

The table is constructed to deal with winds blowing directly along or at right angles to the line of fire, and at angles of 45°, 22½° and 67½° to it. It should be noted that 22½° is ¼ of a right angle, and 67½° is ¾ of a right angle.

To use the table, determine the approximate direction of the wind with reference to the line of fire, and read off the allowance indicated.

In the case of oblique targets having a different range to each end, the mean range to the target should be used, when reading off the allowance.

iv. With reference to ii. and iii. above, barometer and temperature readings, and the strength and direction of the wind may be obtained from the "Meteor" wire, which in war is issued by the meteorological section at certain periods during the day.

If this is not available, artillery batteries can usually give the information required.

LESSON 98.—RANGE OR RANGES

Instructor's Notes

1. *Stores as for Lesson 97.*

Explain.—

1. Errors in elevation may be caused by :—

- i. Inaccuracies in determining the range.
- ii. Incorrect allowances for climatic variations.

2. In order to form a basis on which to work, it is assumed that personnel can be trained to give the range within a maximum probable error according to the method employed, as follows :—

- i. By range-finding instrument 5 per cent.
- ii. By estimating from ranges taken with a range-finding instrument 10 per cent.
- iii. From a map of not less scale than 1/25,000 5 per cent.

The error may have been made either way, *i.e.* the range may have been given too long by the whole amount of the error or too short by the whole amount of the error. Thus, a point target cannot be considered as a point but rather as a target which covers in depth a distance equal to twice the probable error in range.

For example.—The range to a point as obtained by range-finding instrument is 1,300 yards.

In this case (Fig. 14) the target must be considered as extending from 1,235 yards to 1,365 yards. Therefore, the whole of this depth (130 yards) must be engaged when fire is opened.

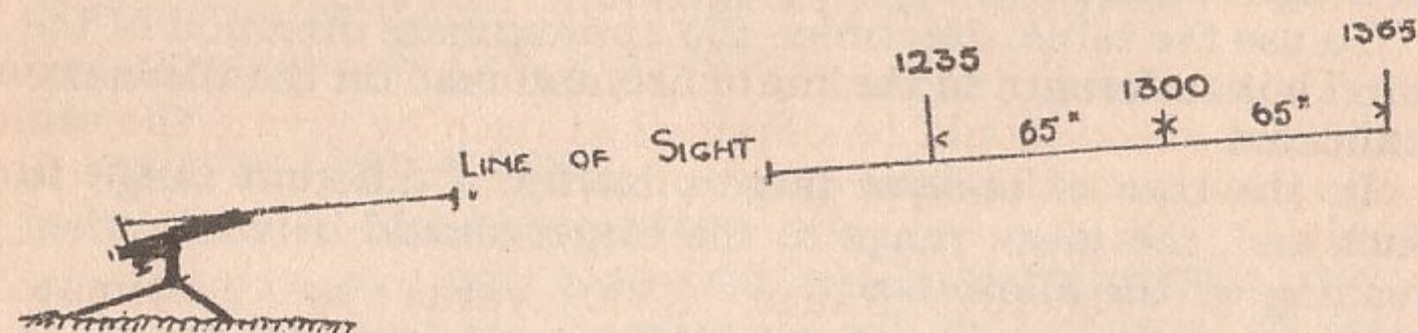


Fig. 14.

3. For all practical purposes it may be taken that the centre shot of the beaten zone cuts the line of sight at a range corresponding to the tangent elevation on the gun, and that half the beaten zone as given in the range table falls beyond this point and half short of it.

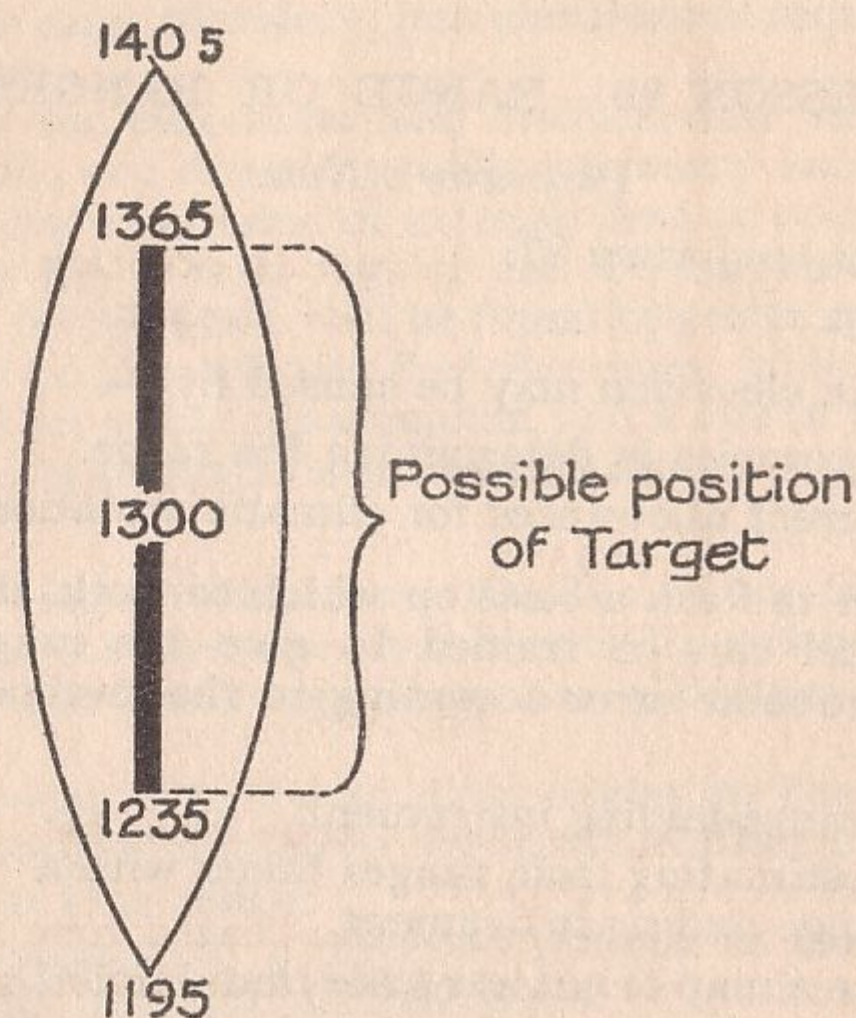


Fig. 15.

4. To decide whether or not fire effect will be obtained on a target when fire is opened, it is necessary to compare the length of the beaten zone at that range with twice the probable error in range.

For example:—

"A". (Fig. 15). Range 1,300 yards by range-finder.
Error either side 65 yards (5 per cent. of range).
Beaten zone 210 yards (*i.e.* 105 yards either side).

Thus the length of the beaten zone covers the probable error and fire effect should be obtained at once by giving the same elevation with the same point of aim to both guns of the fire unit.

"B". (Fig. 16). Range 1,300 yards by "estimated range".
Error either side 130 yards (10 per cent. of range).
Beaten zone 210 yards (*i.e.* 105 yards either side).

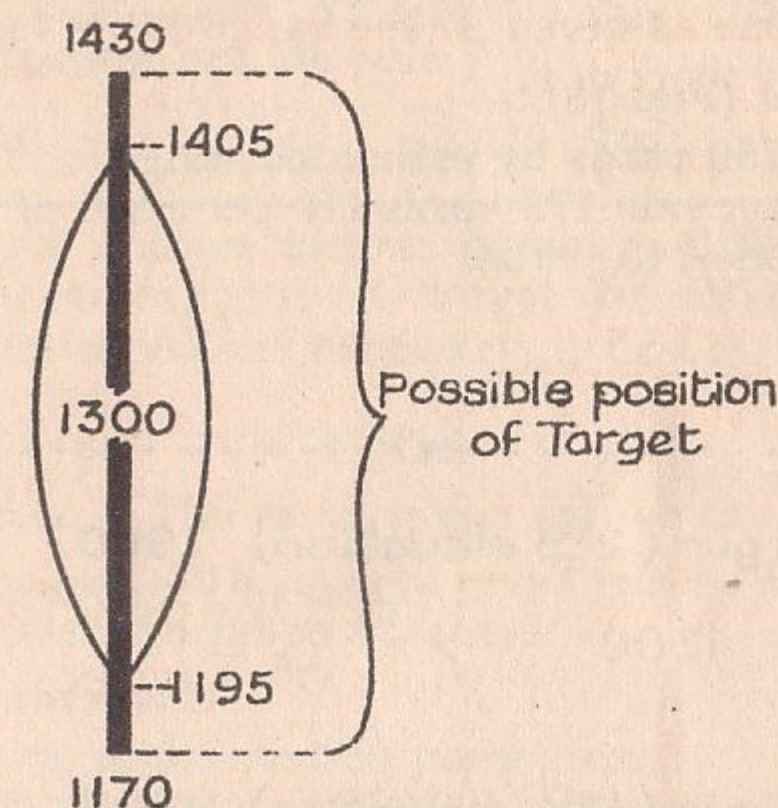


Fig. 16.

Thus the length of the beaten zone must be increased until the necessary depth is engaged.

The increase in the length of the beaten zone is effected by giving one gun an elevation of 50 yards under, and the other 50 yards over the estimated range, both guns using the same point of aim. The beaten zone will thereby be increased by approximately 100 yards. (Fig. 17).

This procedure is termed "using combined sights". When using combined sights, the centres of adjacent beaten zones are always separated by 100 yards. This figure has been chosen as giving a reasonable overlap at all ranges.

At longer ranges, when an "estimated range" is being considered, it may be necessary to use more than two elevations.

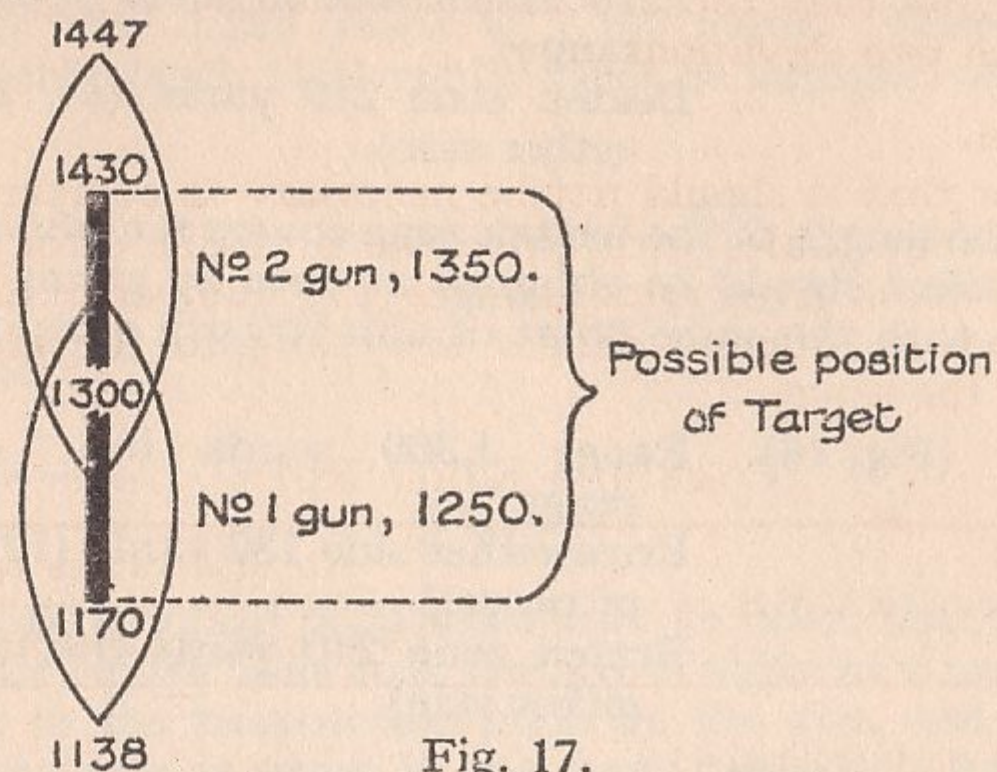


Fig. 17.

For example (Fig. 18) :—

Range 1,750 yards by estimated range.

Error either side 175 yards (10 per cent. of range).

Beaten zone 145 yards.

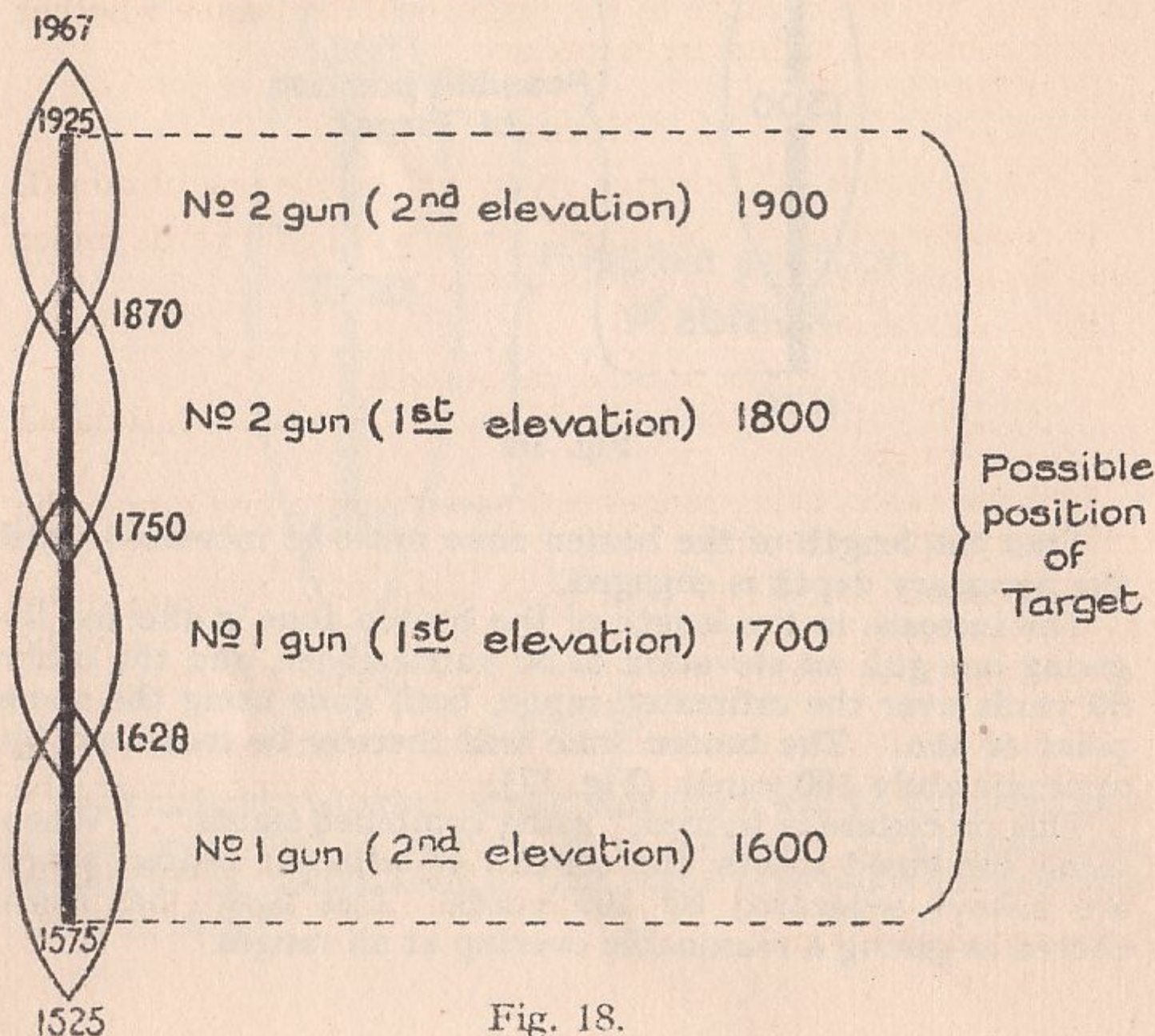


Fig. 18.

Whenever possible, to prevent unnecessary expenditure of ammunition and loss of time, the range-taker should obtain the range, so that the fire unit commander can engage the target with two elevations only.

4. Rule.

In order that it should not be necessary to compare beaten zones in range tables with twice the probable error in range the table below gives rules showing the number of elevations to be used at different ranges according to the method of obtaining the range.

COMBINED SIGHT RULE

RANGE	No. of elevations required	
	5 per cent. error	10 per cent. error
Up to 1,100 yards (inclusive)	One	One
Above 1,100 yards and up to 1,500 yards (inclusive)	One	Two
Above 1,500 yards	Two	Four

In the case of oblique targets having a different range to each end, the mean range to the target will determine whether or not combined sights are necessary.

NOTES

- One elevation.*—The range given will be the one obtained.
- Two elevations.*—The ranges given will be 50 yards under and 50 yards over the range obtained.
- Four elevations.*—
 - 50 yards under and 50 yards over.
 - 150 yards under and 150 yards over the "estimated range".

In a few cases, using ranges estimated from a key range, the rule is approximate only.

iv. *Indirect fire.*—The combined sight rule is applied by firing first all guns on the lower elevation (50 yards below the range) and then lifting 100 yards to the higher elevation.

5. Errors in elevation due to climatic variations other than wind are themselves small and may, in firing direct, be ignored.

Head or rear winds will affect the elevation, but here again, unless the wind is very strong, and the range long, the allowance required is small.

SECTION 24.—DIRECT FIRE

1. The direct fire unit is the section, because :—

- i. Two guns are required to give the necessary volume at machine gun ranges.
- ii. At the longer ranges, two guns are required to ensure hitting the target at the first burst or immediately following it.
- iii. In case of stoppage of one gun, sustained fire can be maintained by the other.
- iv. It can be easily concealed and is not too vulnerable.

2. The requirements of fire control necessitate the two guns being under the command of a fire controller who is supplied with a range-taker to enable him to determine the range.

3. In order to avoid casualties the two guns of a section in action should be as far apart as possible, provided that the section commander is able to control both guns by voice.

4. With reference to para. 1, above, at distances beyond 1,500 yards the volume of fire produced by a section cannot always be relied on to give results proportionate to the expenditure of ammunition, and the fire of two or more sections may have to be directed on to the same target from their respective positions.

LESSON 99.—FIRE ORDERS—DIRECT

Instructor's Notes

Stores :—

Two guns and tripods, two directors, range tables, slide rules, landscape target, blackboard.

This lesson should be carried out indoors with a blackboard and landscape target initially in the form of a lecture.

1. Explain that the following is the procedure for engaging a target by a direct fire unit.

- i. The fire controller, by means of a fire order, gives an elevation and indicates a point of aim on the target for each gun.
- ii. Each firer sets his tangent sight at the elevation ordered, and by tapping the gun, and the use of the elevating handwheel, directs the line of sight on to the point indicated for the gun. Thus the gun is laid initially for both elevation and direction.

2. Fire orders are given in a sequence, laid down in para. 3, below, and must not be departed from.

Rigid adherence to the sequence will ensure that errors and omissions are detected immediately, and, further, that the personnel, knowing what to expect, will act more quickly.

The orders must be given loudly and clearly, the fire controller facing towards the guns.

He must make up his mind what is the correct order to give before embarking on it. Long and unnecessary pauses during which he is coming to a decision as to the next part of the order, can only result in inaccuracies and slovenly drill.

The recipients must have time to act on one portion of the order before another is given.

3. The sequence of a direct fire order is :—

- i. Range or ranges.
- ii. Indication of the target.
- iii. Method of fire.
- iv. Side wind allowance.
- v. Rate of fire (if required).
- vi. Order to fire.

When giving out the order, pauses should be made as under, until it is seen that the gun numbers are ready for the next part of the order.

After the range	To allow time to set the sights.
At various stages during the indication	Time must be given for points to be recognized. When degree methods of indication are used, a pause must be made to enable the angles to be measured.
After method of fire ..	To enable the guns to be laid.
After wind, if any ..	To allow of picking up a gun aiming mark.

4. **Range or ranges.**—

i. Ranges, when ordered to the guns, will be given to the nearest fifty yards, and according to the following examples :—

- 700—Seven hundred.
- 1,000—Ten hundred.
- 1,400—Fourteen hundred.
- 1,450—Fourteen fifty.
- 2,000—Twenty hundred.
- 2,300—Twenty-three hundred.
- 2,350—Twenty-three fifty.

ii. For the first target the section commander will usually obtain the range from the range-taker, but where the situation

demands it, he should not hesitate to estimate the range. For subsequent targets, to save time, ranges are taken, or estimated, from the range card.

iii. One range is given to both guns, or a different range to each gun, in accordance with the combined sight rule. (Lesson 98.)

If one range is ordered to the two guns the range will be preceded by the word "**all**" e.g. "**all—twelve hundred**".

If two elevations are necessary, they will be given in the form :—

"**No. 1—Sixteen fifty**".

"**No. 2—Seventeen fifty**".

iv. Except in the engagement of targets where the right end has a greater range than the left end, No. 1 gun is always given the lower elevation.

v. If the wind is sufficiently high to warrant a correction for elevation, the allowance required will be calculated (Lesson 97) and converted into yards. The range will be corrected before being given out.

5. Indication.—

i. The section commander will indicate the target as laid down in Lessons 62 and 63. It should be noted that when switching from one target to another the last target is often the best aid in indication.

ii. When the dial or handwheel method of indication is used, an additional tap right and left of the target should be included in the method of fire to allow for possible errors.

6. Method of fire.—

i. (a) Order "**right and left...taps**".

Both guns are laid on the centre of the target.

No. 1 gun taps to the left first and No. 2 to the right.

(b) Order "**traversing**".

No. 1 gun is laid on the right end and No. 2 on the left end of the target.

NOTE.—In engaging an oblique target, this order to traverse will be preceded by "**No. 1 right half—No. 2 left half**".

On completion of the "method of fire" order the section commander will order "**lay**".

7. Side wind.—

The section commander will either estimate the side wind required or calculate it to the nearest tap (Lesson 97). It will be ordered to the guns in the following form :—

"**Wind—right (or left...taps)**".

Nos. 1 tap their guns across by the number of taps ordered, pick up a gun aiming mark, and inform Nos. 2 when ready.

If the allowance required is 1° or more, it should be ordered in degrees. Nos. 1 by means of a hand angle pick up a gun aiming mark.

If no correction is necessary, this heading is omitted from the order.

8. Rates of fire.—

If no order is given, normal is implied.

If it is desired to fire "Rapid", the order will be given after the allowance for wind, if any.

9. The order to fire.—

This will normally be given by the fire controller ordering "**fire**". If more convenient he may signal "**fire**". (See Sec. 13, Signals.)

Attention is called to Lesson 96—Length of bursts.

10. The following orders may be given during a shoot :—

i. "**Stop**".

This order is normally given by signal, the arm being waved horizontally to and fro.

ii. **Ranging corrections.**

(a) *Direction.*

The section commander converts the necessary deflection into taps, which he orders to one or both guns as required. Nos. 1 pick up a gun aiming mark in the new line.

Examples :—

All—...Right two taps.

No. 1—...Left three taps.

(b) *Elevation.*

The section commander decides on the correction, and either gives out a new range or orders "**up**" or "**down**" by the amount required.

Examples :—

All—Fourteen hundred".

All—Up two hundred".

No. 2—Up one hundred".

All—Down fifty".

All—Up 20 minutes".

(Corrections must be in minutes after handwheel method of indication.)

iii. "**Go on**".

This order may be given verbally or by making the signal to fire.

11. Practise squad in open country.

LESSON 100.—METHODS OF FIRE

*Instructor's Notes**Stores :—**Blackboard. Landscape target.**The subject matter will be given in the form of a lecture.*

1. Explain.—

Types of targets which machine guns will be required to engage are classified as :—

- i. Point targets. (Lesson 101.)
- ii. Targets with width (horizontal or oblique) having the same range to each end. (Lesson 102.)
- iii. Oblique targets having a different range to each end. (Lesson 103.)
- iv. Targets with depth. (Lesson 104.)
- v. Area targets. (Lesson 104.)
- vi. Moving targets. (Lesson 105.)

2. i. In all cases except oblique targets which require a different range to each end, and moving targets, successive and overlapping beaten zones from each gun will be applied across the whole width and, where necessary, the depth of the target.

ii. The firer is taught the required strength of tap to displace the line of sight by 15', this being the amount which it is calculated will cause successive beaten zones to overlap slightly at all ranges. This tap is called the "regulation 15' tap".

3. **Errors in direction** may be caused by :—

- i. Wrong estimation of wind.
- ii. Slight inaccuracies of aim, wear in the mounting, etc.

As these errors may act either way, it will be necessary to engage an additional width on either side of the target. Lateral errors will not normally be great, but the beaten zone is narrow and so does not give much help in overcoming them.

The error increases in proportion to the range, and therefore a greater width will require to be engaged at long ranges than at short.

LESSON 101.—POINT TARGETS

*Instructor's Note**Stores :—*

Blackboard, landscape target, field glasses, spotlight apparatus.

1. Explain that errors in direction are overcome by the application of the following rule :—

Up to 1,100 yards inclusive.—The error should be covered by the width of the beaten zone.

Above 1,100 yards.—One tap right and left.

Above 1,500 yards.—Two taps right and left.

2. Illustrate a fire unit engaging a point target at a range of 1,600 yards obtained by range-finder, requiring two taps right and left (Fig. 19).

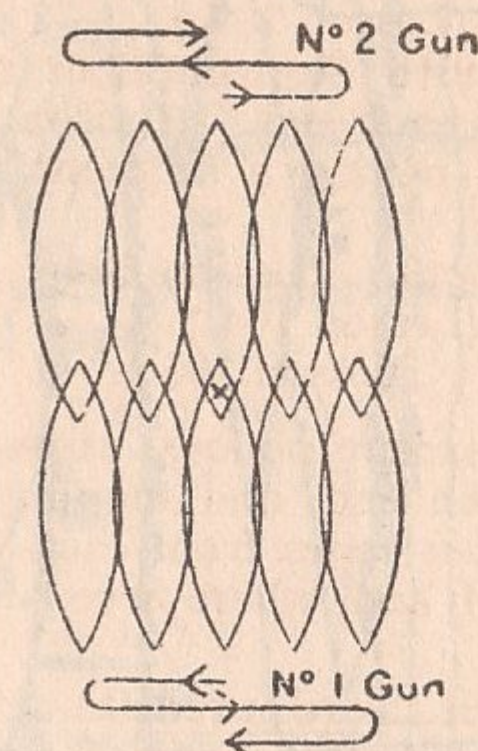


Fig. 19.—Tapping right and left.

3. Explain and show examples that if the point of aim is indefinite (including an indication with the aid of dials or handwheels), an extra tap right and left must be given.

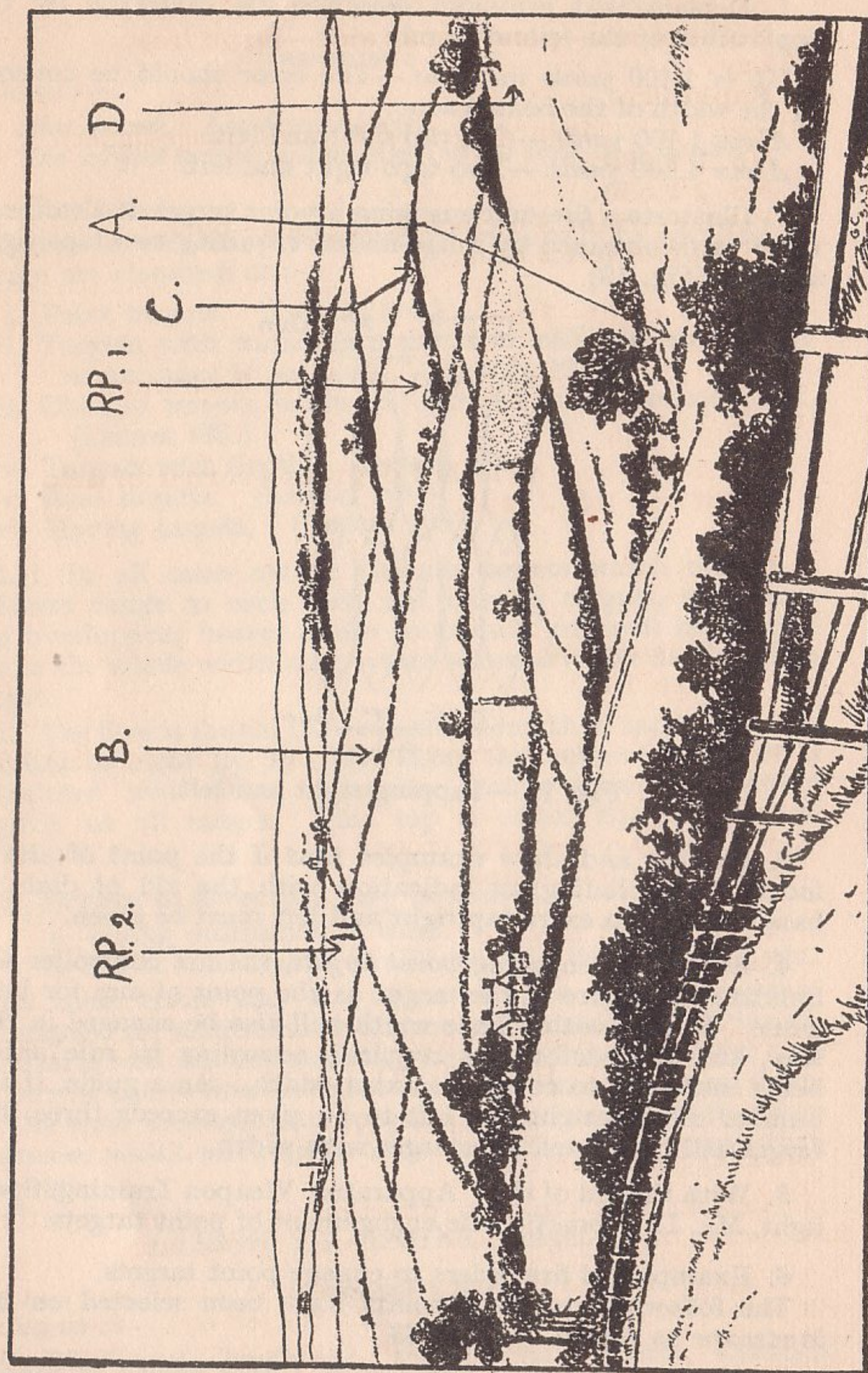
4. Explain in engaging *point targets*, the fire controller will indicate the centre of the target as the point of aim for both guns. Targets with a little width will also be engaged in this way, the number of taps required according to rule above being increased to cover the extra width. As a guide, if the number of taps right and left to be given exceeds three, the target will be treated as a target with width.

5. With the aid of the "Apparatus, Weapon Training, Spotlight, Mk. II." practise the engagement of point targets.

6. Examples of fire orders to engage point targets.

The following reference points have been selected on the landscape as shown in Plate 23.

- i. Haystacks (R.P.1) left bottom corner known as **Stack**.
- ii. Two poplars (R.P.2)—left poplar known as **Poplar**.



Target "A". Point target 850 yards.

All 850.

Right of arc—pond—near side—large tree.

Lay.

Rapid fire.

Target "B". Point target 1,600 yards (range-finder).

No. 1 1,550.

No. 2 1,650.

Poplar—right 3 o'clock 3 degrees—bush.

Right and left 2 taps.

Lay.

Wind—right—1 tap.

Rapid fire.

Target "C". Point target 1,600 yards Estimated.

No. 1 1,550.

No. 2 1,650.

Stack—right 2 o'clock 2 degrees—corner of field.

Right and left 2 taps.

Lay.

Fire.

Stop.

No. 1 down 100.

No. 2 up 100.

Go on.

Target "D". Point target 1,150 yards (range-finder) 45' wide.

All 1,150.

Right of arc—4 large trees.

Right and left 3 taps.

Lay.

Wind—left 1 tap.

Rapid fire.

LESSON 102.—TARGETS WITH WIDTH HAVING THE SAME RANGE TO EACH END

Instructor's Note

Stores as for Lesson 101.

1. Explain that errors in direction are overcome by the firer always traversing outside the flanks by one tap.

2. Explain that in engaging targets with width No. 1 gun will be laid on the right end, No. 2 on the left end. Each gun will engage the whole target. The engagement of a target in this way is known as *traversing*.

3. Illustrate.

A fire unit engaging a target about 100 yards wide, at a range of 1,400 yards obtained by range-finder. (Fig. 20.)

- i. x . . . x are the original points of aim.
- ii. The dotted beaten zones on the flanks of the target represent one tap outside. (See para. 1, above.)

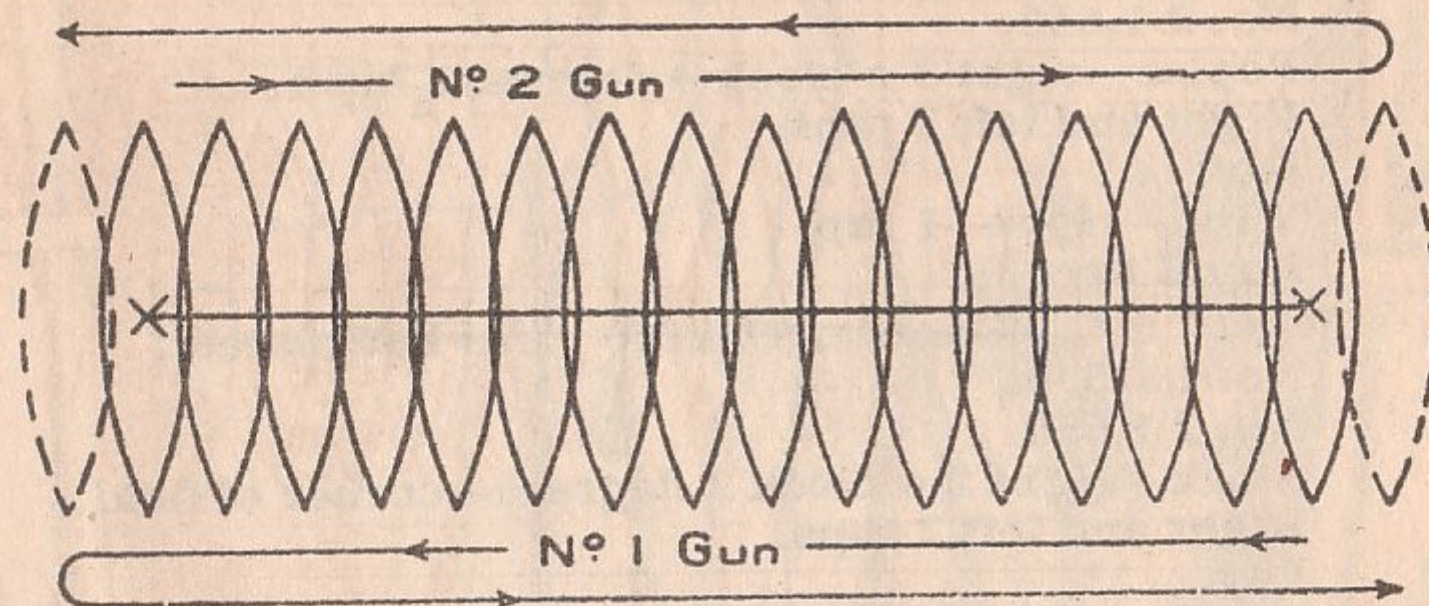


Fig. 20.—Traversing

4. Explain.

It takes about 90 seconds for a gun to traverse across 100 yards. The time taken is approximately the same at all ranges, because, although, as the range increases, the angular amount to be traversed becomes less, the length of bursts must be increased. The greatest target frontage, therefore, which can be engaged effectively by a fire unit of two guns, without undue delay and excessive expenditure of ammunition, is about 100 yards.

5. With the aid of the spotlight apparatus practise the engagement of targets with width.

6. Examples of fire orders to engage targets with width.

The following reference points have been selected on the landscape as shown in Plate 24.

- i. Haystacks (R.P. 1) left bottom corner known as **Stack**.
- ii. Two poplars (R.P.2) left poplar known as **Poplar**.

Reference to Plate 24.

Target "E". Target with width 1,100 yards (estimated).

All 1,100.

Poplar—6 o'clock right end of house—left limit.

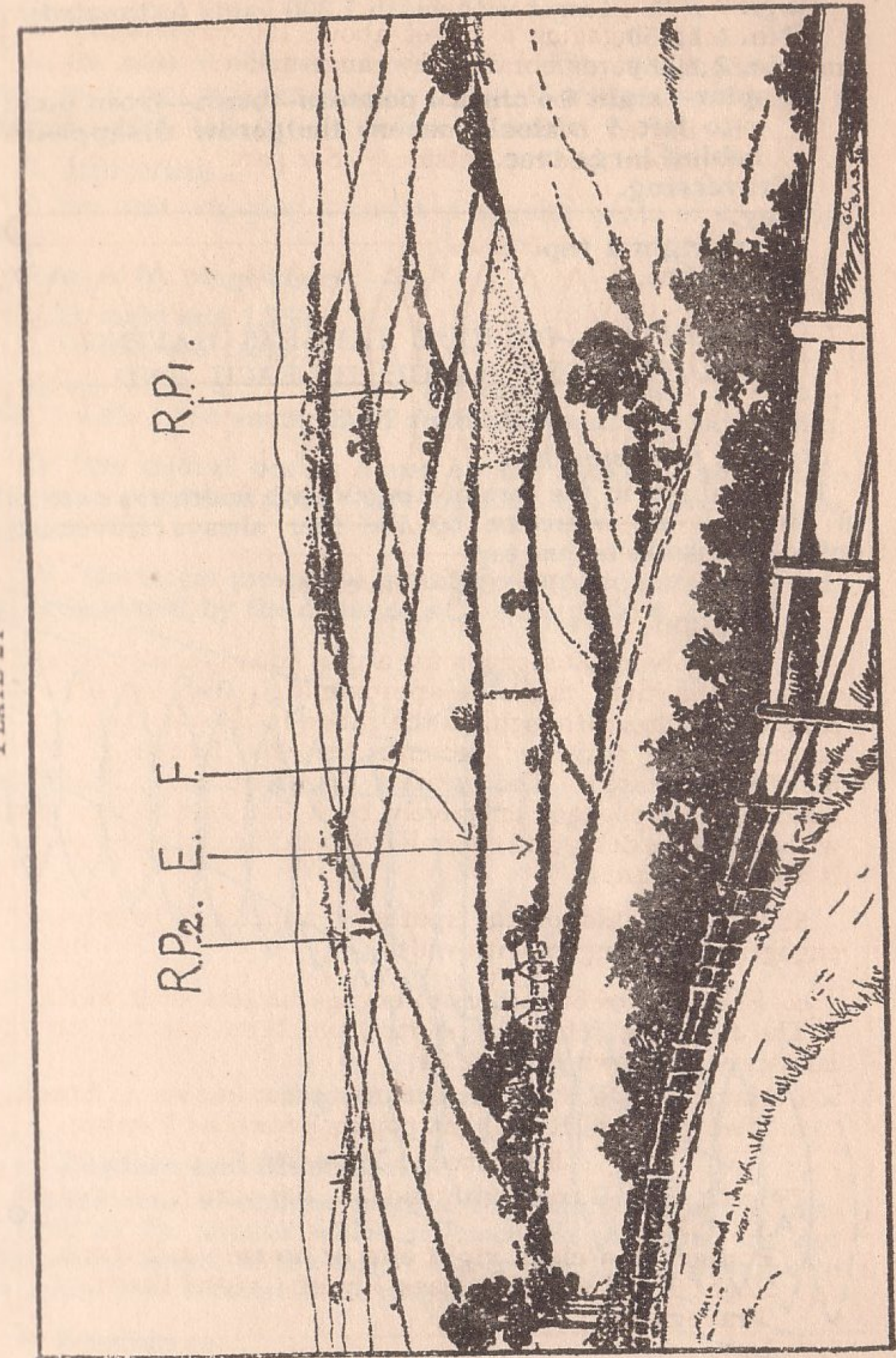
Right 3 o'clock 2 degrees—bush—right limit.

Traversing.

Lay.

Rapid fire.

PLATE 24



Target "F". Target with width 1,300 yards (estimated).

No. 1 1,250.

No. 2 1,350.

Poplar—right 4 o'clock 4 degrees—bush—from bush
—to left 9 o'clock—where hedgerow disappears
behind large tree.

Traversing.

Lay.

Wind right 1 tap.

Rapid fire.

LESSON 103.—OBLIQUE TARGETS HAVING A DIFFERENT RANGE TO EACH END

Instructor's Notes

Stores as for Lesson 102.

1. Explain as in the case of targets with width that errors in direction are overcome by the firer always traversing outside the flanks by one tap.

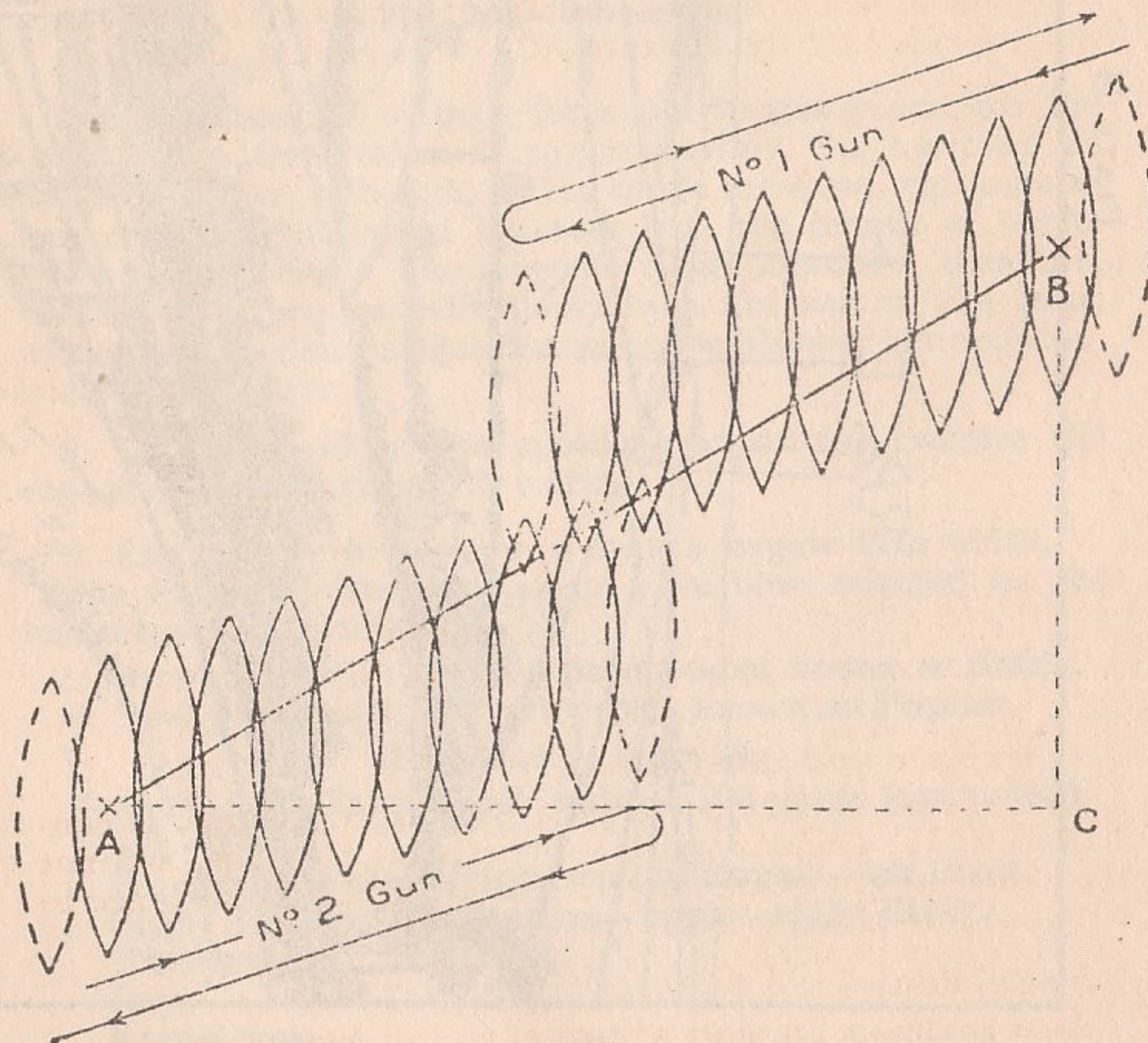


FIG. 21.—Traversing oblique target

2. Explain.—

In the case of oblique targets with a different range to each end, each gun will traverse its own half of the target: No. 1 gun the right half, No. 2 gun the left half.

3. Illustrate.—

A fire unit engaging a target of angular width of 4°. (Fig. 21.)

Ranges by range-finder:—

To right end 1,350.

To left end 1,200.

NOTES.—(1) x . . . x are the original points of aim—No. 1 with 1,350 yards, No. 2 with 1,200 yards on their sights.

(2) The dotted beaten zones on the flanks of each gun's traverse represent one tap outside that traverse. (See Lesson 102.)

(3) The target presents a frontage of approximately 90 yards as represented by the distance AC. (See para. 4, below.)

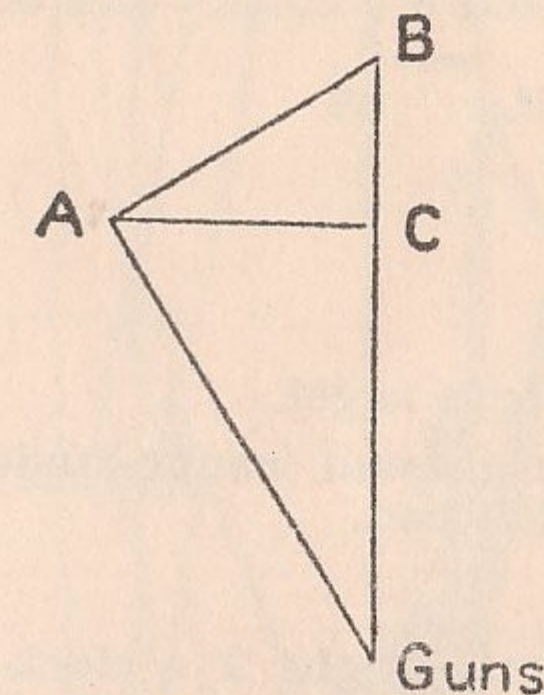


Fig. 22.—Guns.

4. Explain and illustrate.—

In the case of oblique targets, the target frontage is considered as the angular width subtended at the guns, and not the actual length of the target, e.g. in Fig. 22 the distance to be taken into account is AC and not AB.

5. Explain.—

As a guide—a fire unit of two guns can engage an oblique target when the difference in range between the two ends is 2—(370c)

less than about 150 yards. If the difference exceeds that distance, only a portion of the target should be engaged at one time.

6. With the aid of the spotlight apparatus, practise the engagement of oblique targets.

7. Examples of fire orders to engage oblique targets.

The following reference points have been selected on the landscape as shown in Plate 25.

- i. Haystacks (R.P.1) left bottom corner known as **Stack**.
- ii. Two poplars (R.P.2), left poplar known as **Poplar**.

Reference to Plate 25

Target "G" Oblique target.

1,450 yards right end (range-finder).

1,300 yards left end.

No. 1 1,450.

No. 2 1,300.

Poplar—Left 8 o'clock—Junction of hedgerows—right limit—left 8 o'clock—end of hedgerow—left limit.

No. 1 right half.

No. 2 left half.

Traversing.

Lay.

Fire.

Target "H". Oblique target.

1,600 yards right end (range-finder).

1,500 yards left end.

No. 1 1,550.

No. 2 1,450.

Poplar—left limit—right 2 o'clock—trees at right end of church—right tree—right limit.

No. 1 right half.

No. 2 left half.

Traversing.

Lay.

Wind left 2 taps.

Fire.

Stop.

All up 100.

Go on.

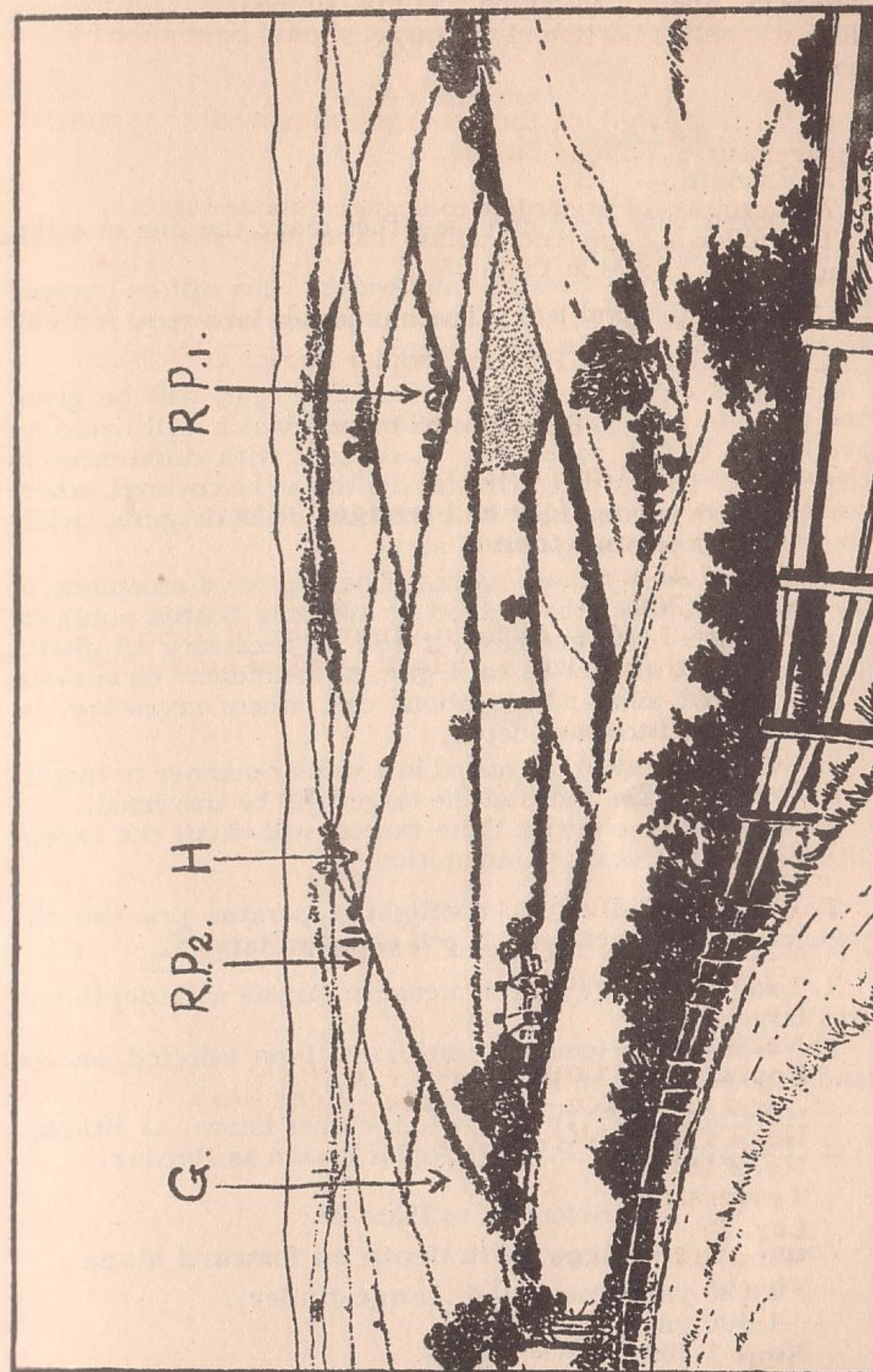


PLATE 25.

LESSON 104.—TARGETS WITH DEPTH AND AREA TARGETS

Instructor's Note

Stores as for Lesson 103.

1. Explain.—

1. *Targets with depth* may be either along the line of sight, or on a forward slope.

Such targets may present some width; this will be covered by tapping right and left. The number of taps required will be calculated using the mean range.

i. *Targets along the line of sight.*—Each gun will be given one point of aim, and each an elevation which will cause an overlap of beaten zones (this is ensured with differences in elevation of 100 yards). Greater depth can be covered, where necessary, by increasing the elevation of both guns, while maintaining the same point of aim.

ii. *Targets on a forward slope.*—The degree of steepness of the slope will affect the method of applying beaten zones on to the target. In some cases it will be necessary to give a different point of aim to each gun, and different elevations. The points of aim and elevations can, where necessary, be lifted to cover necessary depth.

iii. *Area targets* will be treated in a similar manner to targets with depth, but the width of the target will be traversed.

To deal effectively with these targets will entail the expenditure of a great deal of ammunition.

2. With the aid of the spotlight apparatus practise the engagement of targets with depth and area targets.

3. Examples of fire orders to engage targets with depth and area targets.

The following reference points have been selected on the landscape as shown in Plate 26.

- i. Haystacks (R.P.1) left bottom corner known as **Stack**.
- ii. Two poplars (R.P.2) left poplar known as **Poplar**.

Reference to Plate 26.

Target "I". Target with depth on forward slope.

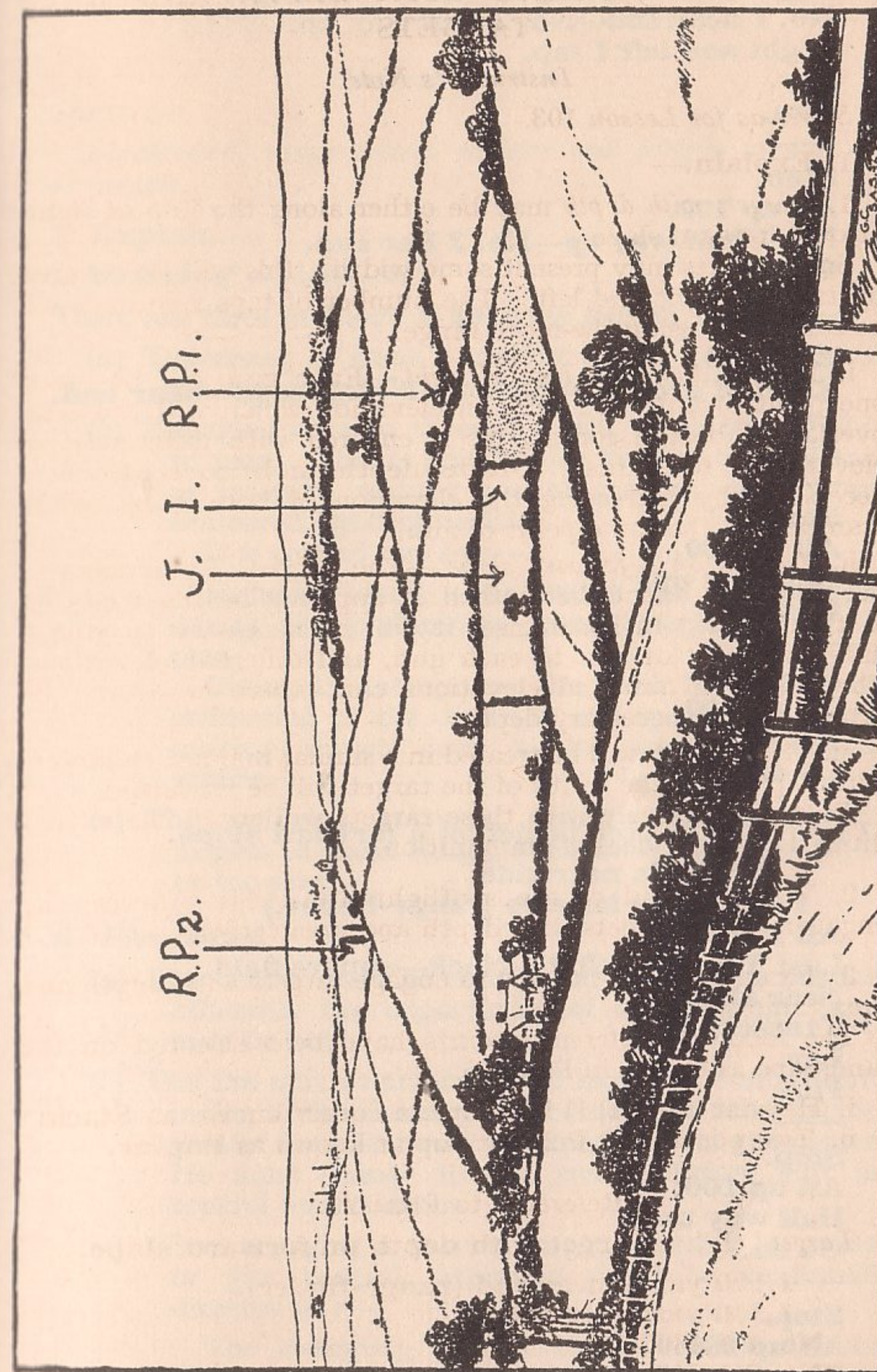
1,100 yards near end (range-finder).

1,300 yards far end.

No. 1 1,100.

No. 2 1,200.

PLATE 26.



Right of arc—ploughed field—left edge.
 No. 1 near end—No. 2 half way up.
 Right and left 1 tap.
 Lay.
 Fire.

—
 Stop.
 All up 100.
 No. 1 half way up—No. 2 Far end.
 Go on.

or

All 1,100.
 Right of arc—Ploughed field—left edge—near end.
 Lay.
 Fire.

—
 Stop.
 All up 100.
 Half way up.
 Go on.

—
 Stop.
 All up 100.
 Far end.
 Go on.

Target "J". Area target on a forward slope.

1,100 yards near side.

1,300 yards far side (range-finder.)

All 1,100.

Last Target—left 9 o'clock—square field.

Near side.

Traversing.

Lay.

Fire.

—
 Stop.

All up 100.

Half way up.

Go on.

—
 Stop.

All up 100.

Far side.

Go on.

LESSON 105.—MOVING TARGETS

Instructor's Note

Stores :—

Blackboard, range tables, vehicles and fatigue men to act as targets.

1. Explain.—

i. *Methods of engagement.*

There are three methods of engaging moving targets :—

(a) Traversing in front ; suitable ranges over 800 yards for engaging a slow moving target.

(b) Engaging an area through which the target is likely to pass. This is suitable for fleeting targets, such as infantry making use of ground, cavalry and armoured fighting vehicles.

It is carried out by :—

Including such areas within the arcs allotted during the preliminary arrangements of the fire plan.

Giving an anticipatory fire order based on quick estimation of the direction and speed of a rapidly moving target such as an armoured fighting vehicle.

(c) The swinging traverse, suitable against moving targets at close range, when other methods would be too slow.

ii. *Fire control.*

(a) Fire orders must be simple and as short as possible, otherwise the opportunity of engaging the target may be lost.

(b) The fire unit commander will maintain control until, owing to the closeness of the range or other factors, greater fire effect may be expected from gun control. He must change to gun control before unit fire control breaks down.

(c) When engaging a moving target, whether by section or gun control, attention must be continually directed to :—

The changing line of sight, horizontally and vertically.

The alterations in range.

The maximum effect will only be obtained by quick judgment and a thorough knowledge of the machine-gun beaten zones.

Fire should be directed in front of the target rather than on to it.

Bearing in mind the limited time that an armoured fighting vehicle will take to pass through the beaten zones, a burst of fire should be of 50-60 rounds, in order to ensure the maximum weight of fire during this period.

2. Refer to Range Table, 1937, page 14.—Allowance for moving targets.

3. Practise in the open on targets at varying speeds and distances.

SECTION 25.—INDIRECT FIRE

1. The indirect fire unit is normally the platoon, because :—
 - i. The gun position is not in view of the enemy, and therefore concealment and control of four guns is possible.
 - ii. Indirect fire is usually employed at the longer ranges, when the fire of four guns is desirable to produce the requisite volume.

The section, however, carries the necessary equipment to employ indirect fire independently. In an indirect fire position the normal gun interval is 15 yards.

2. The opening of fire rapidly and effectively by indirect means depends on accuracy in the use of the various instruments and minute precision in drill. This can only be attained by a high standard of training and frequent practice.

3. The principles and methods laid down in the following sections apply to any number of machine guns that may be grouped together as a fire unit under one fire controller.

The platoon, is referred to throughout for reasons of brevity and simplicity.

It must be realized that the diagrams are not drawn to scale.

LESSON 106.—FIRE ORDERS—INDIRECT

Instructor's Notes

Stores :—

Blackboard, range tables.

The lesson should be carried out in the form of a lecture.

1. Explain.—

The following is the procedure for engaging a target by indirect fire :—

The methods of laying guns by indirect means consist of giving direction to the guns by laying them off a point seen from the gun position. Elevation is calculated from the horizontal plane, and is placed on the gun by means of the dial sight. Both direction and elevation are maintained by means of an aiming mark, usually an aiming post placed in

front of the guns. The clinometer level is another check on the elevation.

2. The form of the orders given and the action to be taken will be found in Sec. 18.

The sequence of an indirect fire order will be :—

- i. Zero lines.
- ii. Angle of switch (if any).
- iii. Elevation or elevations.
- iv. Load.
- v. Distribution (if any).
- vi. Tapping right and left.
- vii. Side wind allowance.
- viii. Rate of fire (if required).
- ix. Order to fire (as for direct fire).

3. Notes on indirect fire orders.

i. Zero lines. (Lesson 107.)

Before giving out angles to the respective guns, the order "**zero lines**" will be given. The angles are given to the nearest ten minutes.

ii. Elevation or elevations. (Lesson 114.)

If a correction for atmospheric influences is necessary, it will be added to, or subtracted from, the angle of sight or Q.A. before the latter is given out. (Lesson 97.)

Angles of sight and quadrant angle are converted to the nearest 5' before being passed to the guns.

The elevation is given to the guns as under :—

All (or No. . . .) . . . hundred,
Plus (or Minus) . . . degrees . . . mins.

or

Elevation all (or No. . . .) . . . degrees . . . mins.

iii. Distribution. (Lesson 113.)

The order for distribution will always start with the pivot gun, for which the order "**nil**" is given. The angles of deflection for the other guns are given to the nearest 10'.

iv. Tapping right and left.

The amount of traverse will be given in "taps", as for direct fire.

Nos. 1 and 2 guns tap to the left first, Nos. 3 and 4 to the right first.

v. Side wind allowance. (Lesson 97.)

The allowance is calculated for the range from the gun position, and ordered to the nearest 10'.

4. Orders during a shoot.

i. Lifts.

If in yards will be given to the guns in the form—

"**All—up . . . yards.**"

If in minutes will be determined from the Range Table, pages 2 and 3, col. 3, and given in the form—

"**All—up . . . mins.**"

This order may be given verbally or by signal as detailed in sub-para. ii (b), below.

ii. Ranging corrections.

(a) Direction.

The amount of switch required is measured by the director, glasses, or by slide rule according to the time available.

The correction may be given verbally, or the following semaphore signals may be employed :—

T . . . **right 30'.**

L . . . **left 30'.**

To double or increase further the corrections, the code letter will be repeated as necessary.

(b) Elevation.

The fire controller estimates the correction required in hundreds of yards, and orders the result in the form :—

All—up (or down) . . . yards.

This order may be sent by semaphore signal as follows :—

U . . . **up 50 yards or 10'.**

N . . . **down 50 yards or 10'.**

To double or increase further the correction, the code letter will be repeated as necessary.

If during the shoot it is seen that any gun or guns are firing over or short as compared with the remainder, the order "**check elevation**" will be given.

iii. The engagement of a fresh target.

(a) Direction.

The fire controller measures the angle of switch for the pivot gun as in sub-para. ii (a), above. So that the lines of fire may be parallel, before switching, he will order the guns to relay on their zero lines with dial sights at zero, by giving the order :—

All—on zero lines.

The angle of switch is then given out verbally, or by signal.

If the switch is very large, it may be convenient to correct the zero line on to the new target; in this case, the order for

the angle of switch will be preceded by the words "**zero lines**". When time allows, the aiming posts should be put out to suit the new zero line.

(b) *Elevation.*

The angle of sight to the new target is taken with a director.

The elevation for the new target is calculated and ordered to the guns as in 3 (ii), above.

(c) The remainder of the fire order is normal, depending on the type of target.

(d) During pauses in the firing, and at any other time when it is possible, it is the duty of the fire controller to measure switches, and, with the assistance of his range-taker, calculate the elevation for all probable targets in his arc. This may reduce the time taken to open fire on new targets.

LESSON 107.—GENERAL PRINCIPLES

Instructor's Note

Stores:—

Blackboard.

1. **Explain.**—

i. *Zero lines.*

Lines which are parallel, when swung through the same angle, remain parallel.

Therefore, to provide a basis from which fire can be switched in any direction, all guns are, by various means, initially placed on parallel zero lines. (See Fig. 23.)

The choice of the actual direction of the zero lines is arbitrary but they are generally laid out so that the line of fire of one of the guns will fall on its correct position on the first target, either directly or after an angle of switch has been given. This gun is known as the pivot gun, and is usually one or other of the flank guns.

ii. *Gun frontage.*

The gun frontage is the distance between the flank guns, normally 45 yards for a platoon. When the line of fire is approximately at right angles to the gun position, which is usual, it can be seen from Fig. 24 that the width which is covered by the lines of fire of a platoon on parallel lines is equal to the gun frontage. As the guns are approximately equidistant from one another, the lines of fire of Nos. 2 and 3 guns divide this width into three equal parts, namely, AB, BC, CD.

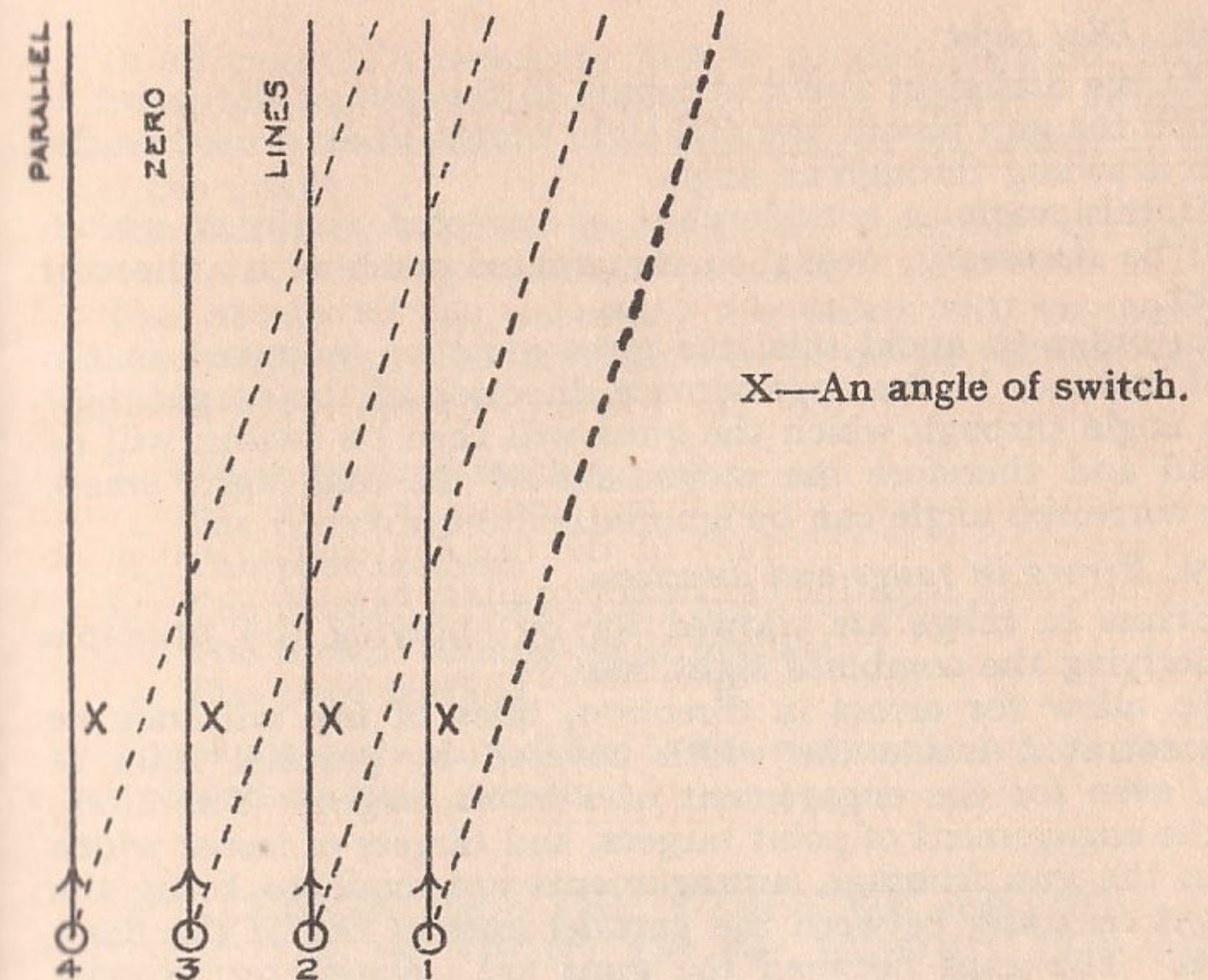


Fig. 23.

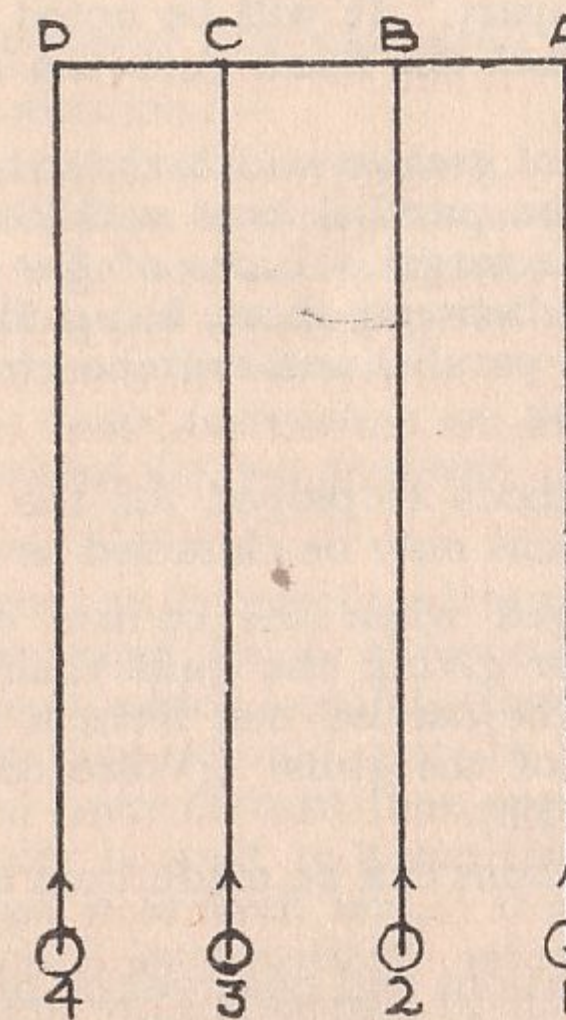


Fig. 24.

iii. *Dial sight.*

As the dial sight is not attached to the gun at the point at which the gun pivots, the dial sight moves in an arc when the gun is swung through an angle.

If this angle is considerable, a corrected angle of sight will be necessary, owing to the altered position of the dial sight.

In order to avoid this, the guns must be mounted in the first instance in the approximate direction of the target. As the angle through which the guns will then be swung will be small and therefore the movement of the dial sight small, the corrected angle can be ignored.

iv. *Errors in range and direction.*

Errors in range are allowed for by applying the principle underlying the combined sight rule.

To allow for errors in direction, lines of fire will not be concentrated inside the width covered by parallel lines of fire, even for the engagement of a point target. Therefore, in the engagement of point targets, and targets of lesser width than the gun frontage, arrangements are made to bring the target centrally between the parallel lines of fire of the flank guns. The gaps between the guns are covered by tapping right and left one tap, this being sufficient to cause the beaten zones to overlap laterally at all ranges, provided guns are not more than 15 yards apart. It will be noted that additional width is covered in that the flank guns tap outside the gun frontage by one tap.

When the target is of greater width than the gun frontage, guns are first placed on parallel lines with the pivot gun on its own portion of the target. Lines of fire are then either opened out, the gaps between them being filled by tapping right and left, or kept parallel and switched from one portion of the target to another.

2. The various methods employed for the engagement of targets by indirect means may be classified as under :—

- i. Methods employed when the control of fire and the calculations for giving the guns their elevation and direction can be carried out from a position within voice control of the guns. (Voice control methods. Lessons 108–112.)
- ii. When all calculations can be made from a map. (Lesson 122.)
- iii. When the calculations and observation of fire have to be carried out at some distance from the guns. (Lesson 123.)

In all cases it is necessary first to parallel the guns, lines of fire then being opened out to cover the target if necessary. Elevation is obtained by measurement of the angle of sight and the range.

The following sections deal with the theory of the various methods of carrying out these processes.

The details of the necessary fire orders will be found in Lesson 106, and the procedure is given in platoon drill—indirect fire. (Sec. 18.)

3. **Voice control** methods are :—

- i. The director method.
- ii. The post method.
- iii. The distant aiming-point and post method.
- iv. The distant aiming-point method.
- v. The crest method.

These methods only differ in the manner in which the guns are placed on their zero lines.

LESSON 108.—THE DIRECTOR METHOD (DIRECTOR IN FRONT OF OR BEHIND THE GUNS)

Instructor's Notes

Stores :—

Director, two guns with dial sights and tripods, blackboard.

Method of instruction :—

The theory will first be explained.

The guns will then be mounted out of doors. The instructor will choose a target so that the director can be mounted between the gun position and the target, and will then give individual instruction in use of the director.

When those under instruction are proficient the director will be mounted behind the gun position.

1. **Explain.**—

i. The director can be employed to parallel the guns when a position can be found for it, either in front of or behind the gun position, from which both the target and the guns can be seen. This position should not be closer than 50 yards to the guns, nor more distant than approximately 150 yards.

ii. The director is used to place the guns on lines parallel to that on which it is itself laid. Therefore the point on the target on which it lays initially will depend on the position of the instrument with reference to the gun position.

For example, consider a target of the same width as the gun frontage. (Lesson 107.)

It is required to bring the line of No. 1 gun on to the right flank of the target (T_1 , Fig. 25) and the remaining guns on parallel lines. Suppose the director is in position at O_1 .

In order that the zero line of No. 1 gun G_1T_1 should fall on the right flank of the target when placed parallel to the initial line of the director sight, it will be necessary for the director to be laid as much to the left of T_1 as its position is left of No. 1 gun, that is at X_1 .

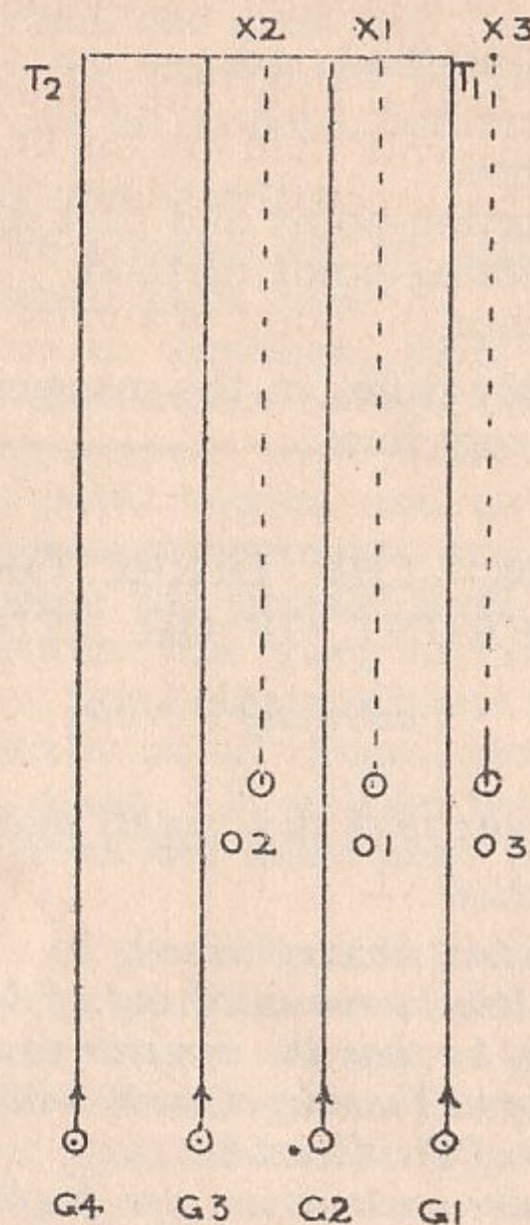


FIG. 25.

Similarly, if the director were at O_2 in the centre of the gun position, it must be laid at X_2 in the centre of the target.

If it were at O_3 outside the gun line, it must be laid at X_3 .

iii. In practice, the position at which the director is set up will depend on the type of target. For targets with width equal to, or greater than, the gun frontage, a position as near as possible to the required zero line of one of the flank guns is most suitable. For point targets or targets of little width a central position will give the best results.

2. Procedure.

i. Set up the director in front of or behind the gun position with the arrow on the index plate set at 180° on the degree scale plate, and the index plate clamp tightened.

ii. Loosen the clamping screw of the clamping socket and lay the telescope on the selected point of aim on the target. Tighten the clamping screw.

iii. Release the index plate clamp and lay on the collimator of the dial sight of each gun in turn.

Read the angle for each gun off the degree scale and give it out to the gun concerned.

Each gun puts on its dial sight the angle ordered and lays on the director. Guns will then be on lines parallel to the initial line on which the director was laid.

3. Theory.

Reference Fig. 26, X is the point of aim on the target selected for the director.

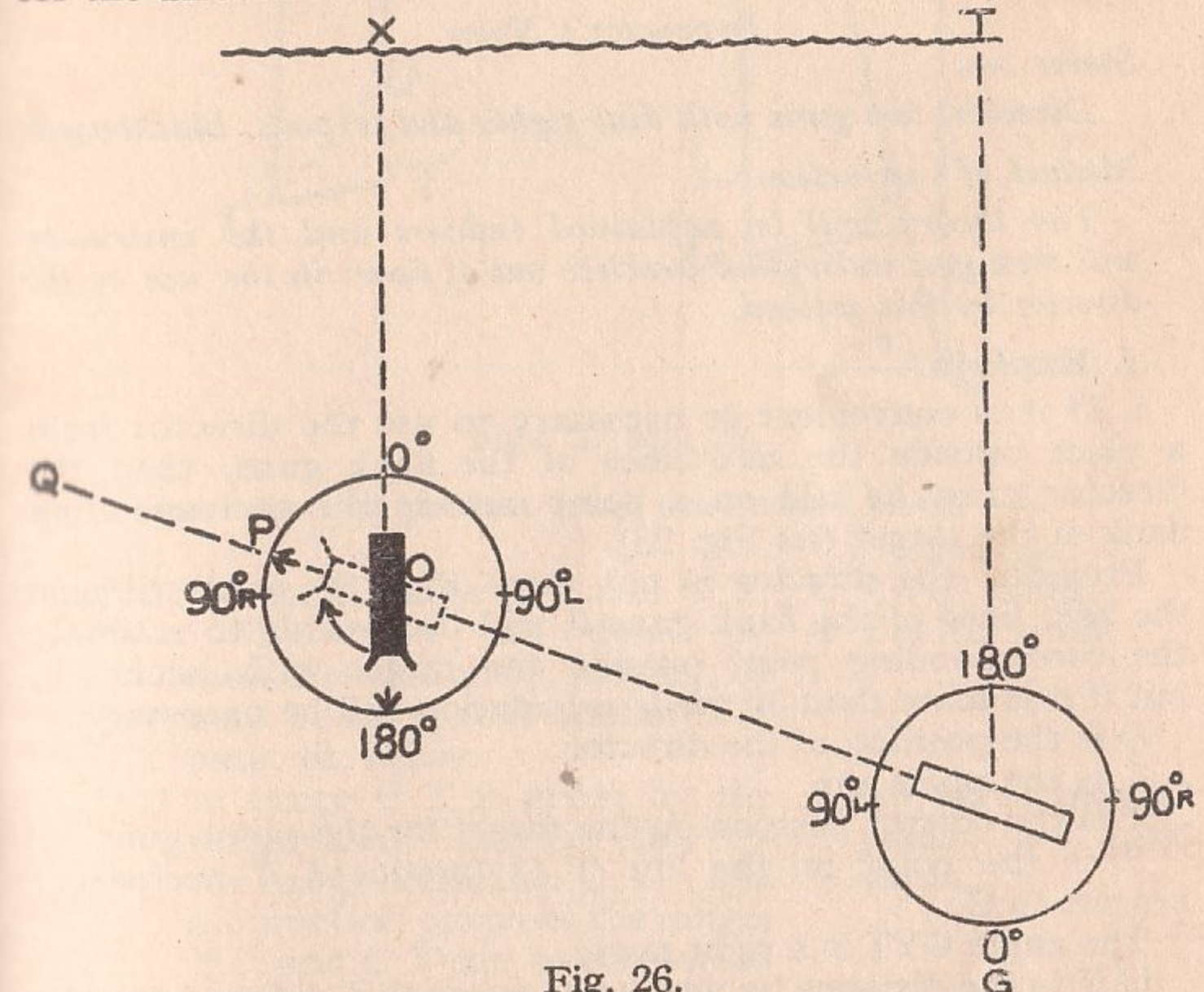


Fig. 26.

QOG is the line joining the director and the gun.

It is desired to place GT parallel to OX .

If the angle TGQ is made equal to XOQ , GT will be parallel to OX .

The position of the telescope when the arrow on the index plate is set at 180° and the telescope laid on the target is shown at O in black. When the telescope is swung round and laid on the collimator, it will be in the dotted position and the arrow on the index plate will have moved round from 180° to a position P on the degree scale plate. As the scale on the degree scale plate runs from 0° through 90° R to 180° as shown in the figure, it can be seen that the reading opposite P will be that for the angle XOQ. The angle XOQ having been set on the direction dial of the dial sight, the gun is laid, by means of the dial sight, on the director.

Thus the angles XOQ and T.G.Q are equal, and therefore GT and OX are parallel.

LESSON 109.—DIRECTOR TO THE FLANK OF THE LINE OF FIRE

Instructor's Notes

Stores :—

Director, two guns with dial sights and tripods, blackboard.

Method of instruction :—

The theory will be explained indoors and the instructor will then give individual practice out of doors in the use of the director by this method.

1. Explain.—

i. If it is convenient or necessary to use the director from a place outside the zero lines of the flank guns, then the director must be laid on a point outside the corresponding flank of the target (see Fig. 25).

Provided the director is not more than 30 yards outside the zero lines of the flank guns it will be possible to estimate the corresponding point outside the target with accuracy, but if it is more than 30 yards calculation will be necessary.

O is the position of the director.

G is the pivot gun.

T is the correct position on the target for the pivot gun.

Y is the point on the line T O (produced if necessary) nearest to G.

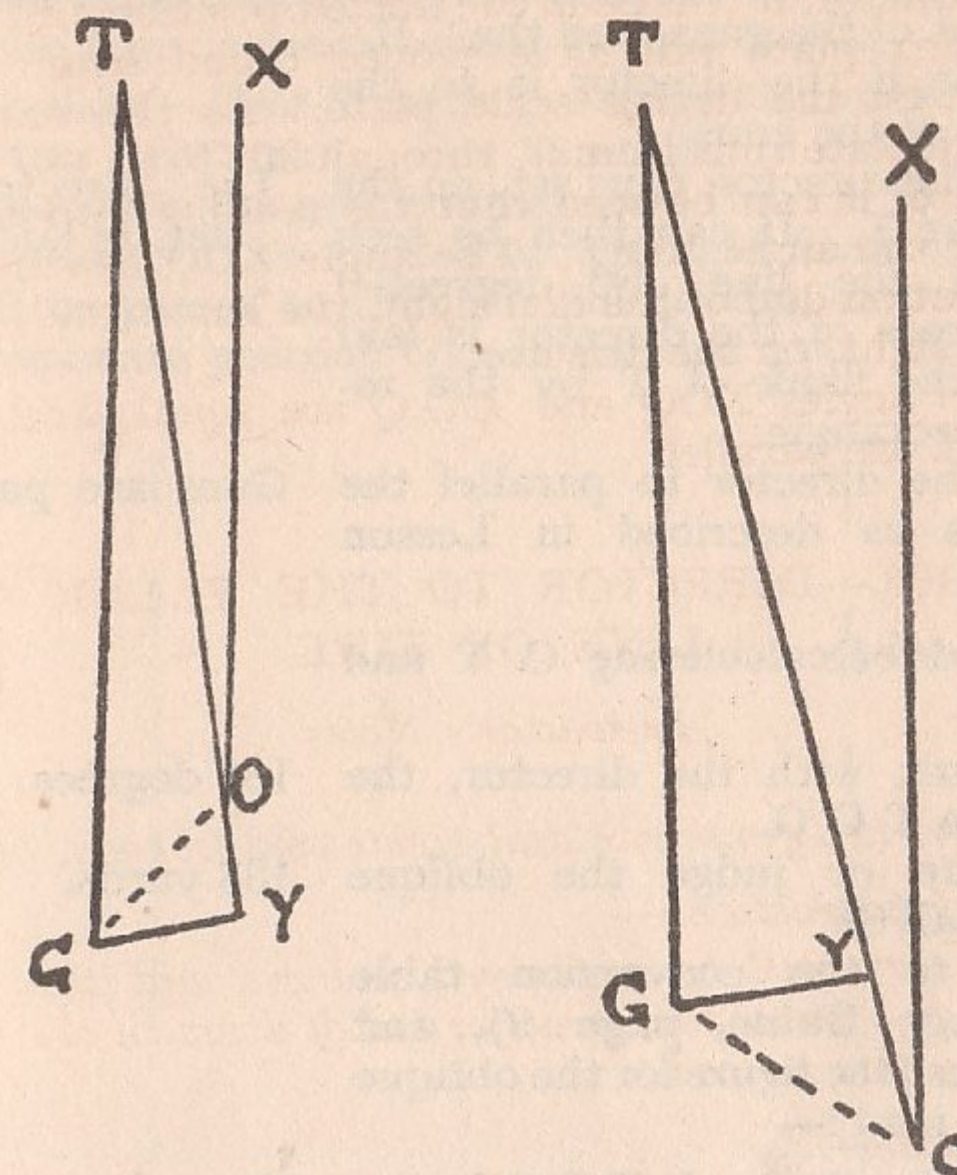
The angle GYT is a right angle.

O Y is the distance by which the range O T differs from the range G T, called the range correction.

G Y is the distance of the displacement of the director, called the true base.

A simple method of laying the director along the required line O X is to find the angle G T O, which is equal to the angle

T O X when the lines G T and O X are parallel, and then to lay the $180-0$ degrees line of the director outside the flank of the target by that angle.



Figs. 27 and 28.

ii. The following process gives the desired result :—

Example.

- (a) Find the distance O Y and G Y. O Y = 87 yards.
G Y = 103 yards.

This may be done by measurement or by judging, or may be calculated as shown in para. iii. below.

- (b) The range O T is given by the range-taker. Correct this by the range correction O Y. For all practical purposes the ranges Y T and G T can be considered equal.

1,920 yards plus 87 yards is 2,007 yards.

- (c) From the slide rule or the V.I. Table (Range Table, page 12), find the angle subtended by the true base G Y at the gun range G T.

103 yards at 2,000 yards subtends three degrees.

- (d) Set the pointer of the director away from the 180 degrees mark by this angle, using the "L" scale if the director is to the right of the guns, and the "R" scale if the director is to the left of the guns. Director is set three degrees away from 180 degrees on the "L" scale.
- (e) Lay the director, thus set, on the point T. It can then be seen that the line 180 degrees-0 degrees of the director is laid to the flank of T by the required angle. The director, thus set, is laid on T.
- (f) Use the director to parallel the guns as described in Lesson 108. Guns are paralleled.
- iii. Method of calculating O Y and G Y.
- (a) Measure, with the director, the angle T O G. 130 degrees.
- (b) Measure or judge the oblique base O G. 135 yards.
- (c) Turn to the conversion table (Range Table, page 9), and against the figure for the oblique base read :—
- Under the angle T O G in the upper heading, the range correction O Y. 87 yards.
- Under the angle T O G in the lower heading, the true base G Y. 103 yards.

NOTE.—O Y and G Y can be calculated on the slide rule (see Lesson 40).

LESSON 110.—POST METHOD

Instructor's Notes

Stores:—

Two (or more) guns with tripods and dial sights. Two zero posts. Blackboard.

Method of instruction:—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

Explain.—

i. This method is suitable when the guns can be brought into action close behind a crest, and the use of the director to parallel the guns is inconvenient or inadvisable.

ii. *Procedure.*—Two or more posts are aligned on the correct line for the pivot gun. For example, if the width of the target is equal to the gun frontage, and No. 1 is to be the pivot gun, the posts will be aligned on the right flank of the target. They will be placed so that the line joining them passes over the approximate position chosen for that gun. (Fig. 29.)

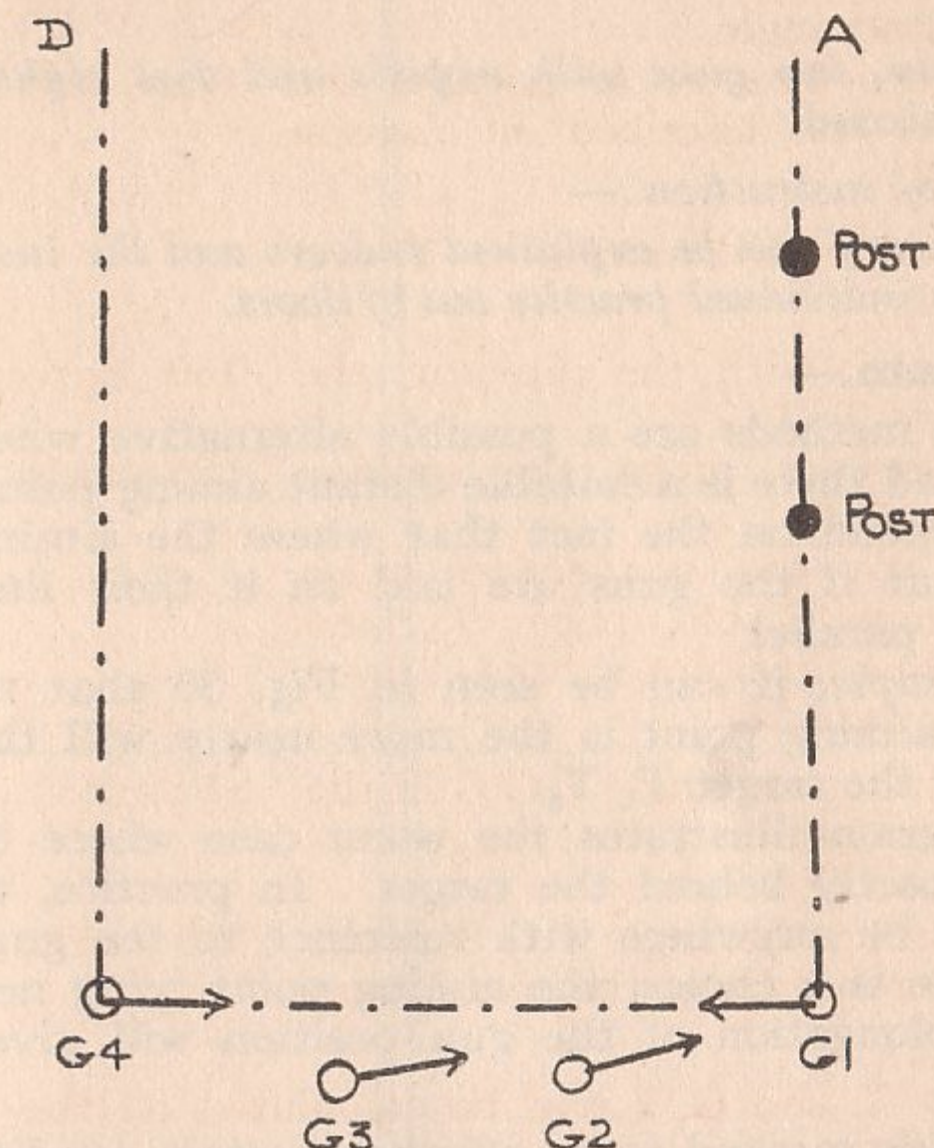


FIG. 29.

Both posts, or any two, if more than two have been used, must be visible from this position at gun height. When the guns are brought up the pivot gun is mounted in direct alignment with the posts with its dial sight at zero, and the gun is laid on them. It will then be on its zero line.

The remaining guns are mounted so that they have an uninterrupted view of the pivot gun, and can be placed on parallel lines to the pivot gun, as follows :—

- (a) The dial sight of the pivot gun is laid on the collimator of the dial sight of each other gun in turn and the angle read out, using the front pointer.

- (b) The other guns put on their dial sights their respective angles as ordered and then tap their guns until their dial sights are laid on the collimator of the dial sight of the pivot gun.
- (c) When this process is complete all guns will be parallel and dial sights will then be reset at zero.

LESSON 111.—A. DISTANT AIMING POINT AND POSTS METHOD—B. DISTANT AIMING POINT METHOD

Instructor's Notes

Stores:—

Director, two guns with tripods and dial sights, two zero posts, blackboard.

Method of instruction:—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

1. Explain.—

i. These methods are a possible alternative when speed is essential and there is a suitable distant aiming point.

They depend on the fact that where the aiming point is very distant if the guns are laid on it their lines will be practically parallel.

For example, it can be seen in Fig. 30 that the further away the aiming point is the more nearly will the guns be parallel on the target $T_1 T_2$.

The diagram illustrates the worst case where the aiming point is exactly behind the target. In practice, the aiming point may be anywhere with reference to the gun position. When there is a choice, the aiming point lying nearest to a line in prolongation of the gun position will give the best results.

ii. For this method to be effective certain conditions must be fulfilled:—

- (a) When the aiming point is in prolongation of the gun position it may be as close as 1,000 yards.
- (b) When the line joining the aiming point to the gun position is at an angle of not more than about half a right angle to the gun position or the gun position produced, the aiming point may be as close as 4,000 yards.
- (c) When the line joining the aiming point to the gun position is at a greater angle than this to the gun position, the aiming point should be about 7,000 yards distant.

2. Procedure.—

A. Distant aiming point and posts method.

A director is mounted in direct prolongation of the posts and the angle between the posts and aiming point is measured.

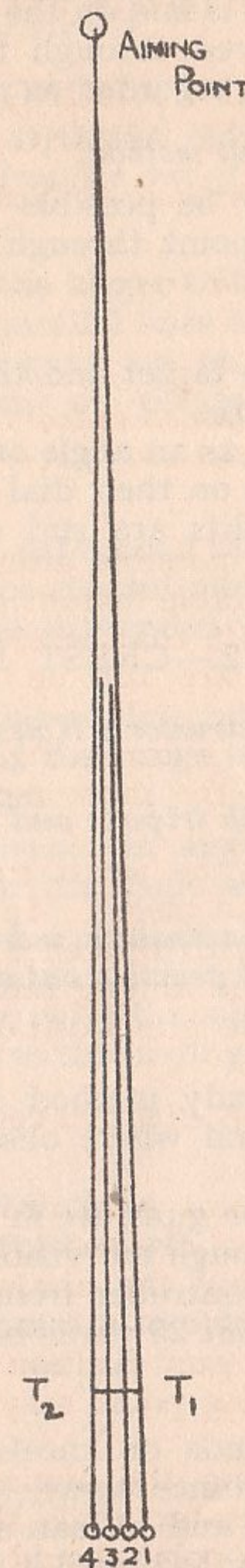


Fig. 30.

The guns are mounted with the pivot gun approximately over the spot from where the director measured the above angle.

This angle is given out as an angle of switch.

All guns put this angle on their dial sights, and are tapped over until their dial sight is laid on the aiming point.

As they have all moved through the same angle off the aiming point they can be regarded as parallel.

B. Distant aiming point method.

i. Occasionally it may be possible to see both the target and the distant aiming point through a director mounted in the gun position.

ii. Procedure.

The angle between the target and the distant aiming point is measured with a director.

This angle is given out as an angle of switch.

All guns set this angle on their dial sights, and are tapped over until their dial sights are laid on the distant aiming point.

LESSON 112.—CREST METHOD

Instructor's Notes

Stores:—

Two or more guns with tripods and dial sights.

Method of instruction:—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

1. Explain.

This is a rough-and-ready method for use at ranges not exceeding 1,500 yards, and where observation of strike will probably be obtained.

It can be used when the guns are in action just behind the crest, and the target, although not visible from the gun height, can be seen by the fire controller from any position directly behind the guns up to about 25 yards back.

2. Procedure.

The fire controller stands or kneels behind each gun in turn at a convenient distance away. He orders the No. 1 to raise the tangent sight and to lean aside. He then orders him to tap the gun right or left until it is laid on to its correct position on the target.

LESSON 113.—DISTRIBUTION

Instructor's Notes

Stores:—

Director ; range tables and slide rules ; two or more guns (with tripods and dial sights).

Method of instruction:—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

1. Explain.

When the width of the target to be engaged is greater than the gun frontage, the parallel lines of the guns may be opened out so that the flank guns are on the flanks of the target, and the remaining guns on points which divide the target into three equal parts.

2. Procedure.

i. Measure the angle subtended by the target at the observation post. In the voice control methods this can be taken as the same as the angle subtended by the target at the gun position.

ii. From the V.I. table or slide rule find the angle subtended by the gun frontage at the range to the target, and subtract this angle from the first.

iii. Divide the difference in angle by the number of gun intervals. This will be the angle of distribution.

iv. The gun next to the pivot gun is swung away from the line of the latter by the angle of distribution, the gun two away from the pivot gun by twice the angle of distribution, and the gun on the other flank to the pivot gun by three times the angle of distribution.

Example:—

Range to target 1,800 yards.

Angular width of target $3^{\circ} 50'$.

No. 4 is pivot gun.

45 yards (gun frontage) subtends $1^{\circ} 27'$ at 1,800.

$$\begin{array}{r} 3^{\circ} 50' \\ 1^{\circ} 27' \\ \hline 3)2^{\circ} 23' \\ \hline 48' \end{array}$$

Distribution—No. 4 Nil.

No. 3 R. 50'

No. 2 R. $1^{\circ} 40'$ ($2 \times 48'$).

No. 1 R. $2^{\circ} 20'$.

NOTE.—Angles given out to guns to nearest 10'.

Note.—In the case of oblique targets having a different range to each end, the mean range will be used for calculating the angular width of the gun frontage.

3. Theory.

In Fig. 31.

T_1T_2 is the target.

No. 1 (G_1) is the pivot gun.

G_2P , G_3Q , G_4R are the zero lines of Nos. 2, 3 and 4 guns

It is required to place the lines of Nos. 2, 3 and 4 guns at B, C and T_2 , where B and C divide the target into three equal parts.

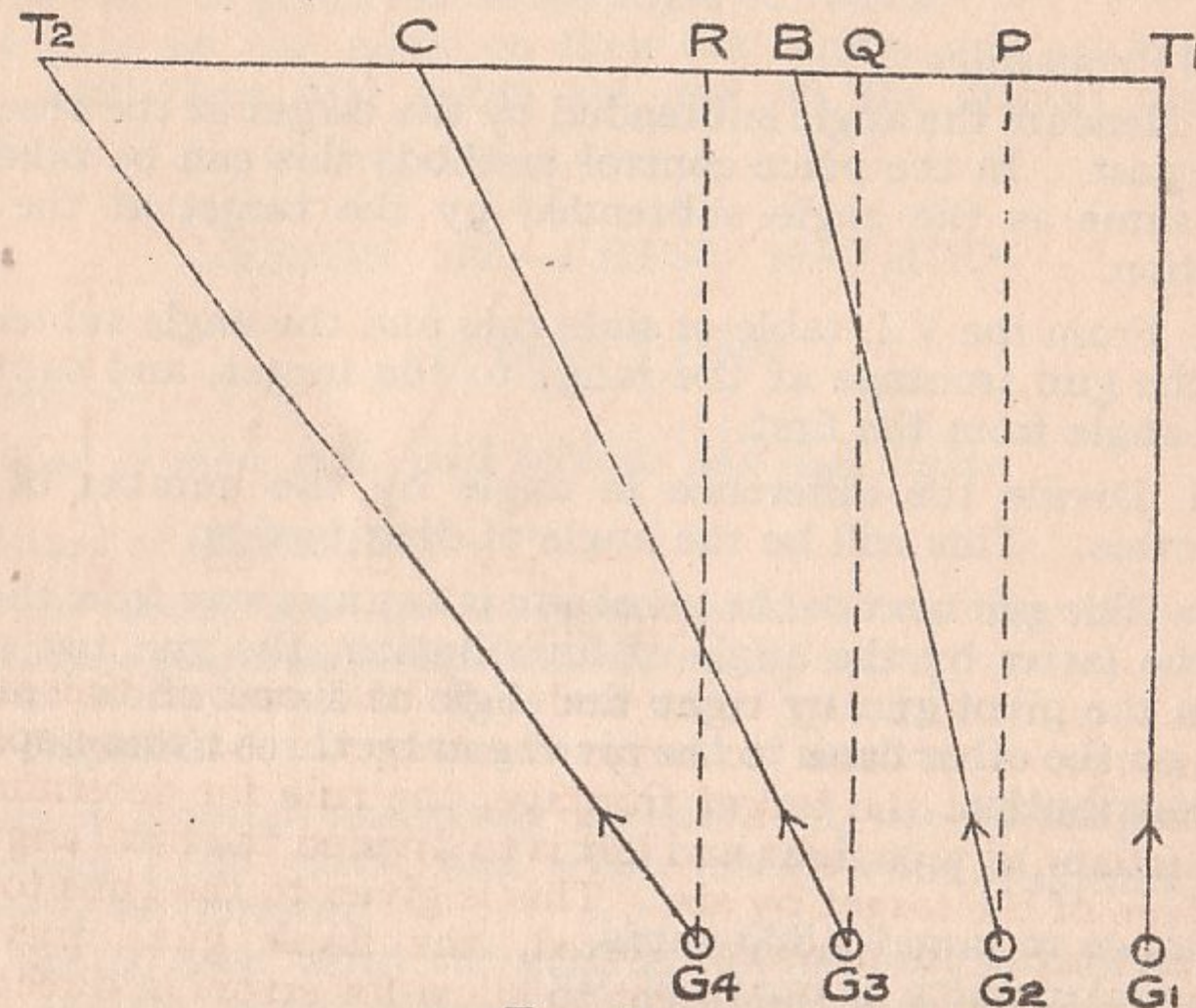


FIG. 31.

Now P is already one-third of the way along T_1R . If, therefore, we can switch No. 2 to B, where PB is equal to one-third of RT_2 , B will be one-third along the whole distance T_1T_2 .

Similarly for No. 3 gun, Q is already two-thirds of the way along T_1R ; to place it at C, therefore, two-thirds of RT_2 must be added to T_1Q .

No. 4 gun must be moved to the left by the whole amount of RT_2 to bring it on to the left flank of the target.

In the procedure given, by subtracting the angular width of the gun frontage from the angular width of the target, we get the angular width of RT_2 . This divided by three gives the angle of distribution.

4. It can be seen from Fig. 32 that when the lines of fire have been opened out only four points, T_1 , B, C and T_2 are struck by the beaten zones. It is necessary, therefore, to tap right and left so that the intervening spaces are engaged.

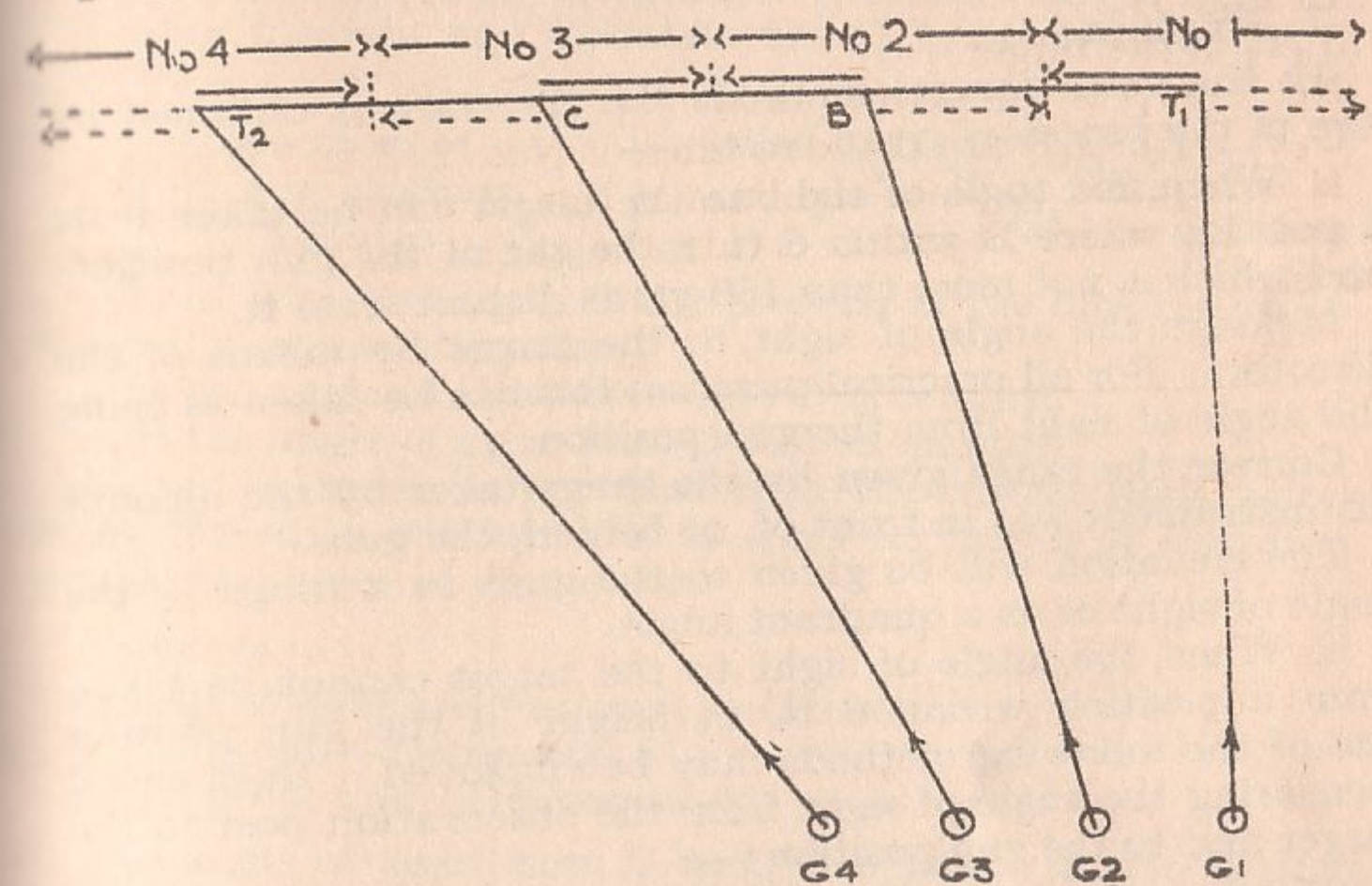


Fig. 32.

Each gun must tap right and left half one of the intervening spaces in order to cover the target. As these spaces are one third of the target frontage, the rule for determining the amount of taps right and left is to divided the total angular frontage of the target by six. This is given to the guns to the nearest tap. As already stated, the flank guns traverse outside the flanks of the target to allow for errors in direction.

Since one gun cannot engage, with the best effect, more than about 50 yards of frontage, the width T_1T_2 should not exceed about 150 yards.

5. Targets with width greater than the gun frontage can be engaged either by opening out the lines of fire by means of distribution or by keeping the guns on parallel lines and switching them from one portion of the target to another. The method employed will depend on the nature of the target and the time available.

LESSON 114.—OBTAINING ELEVATION

*Instructor's Notes**Stores:—**Blackboard, range tables, directors.**Method of Instruction:—**The procedure will be explained indoors. The squad will be practised with examples and the instruction completed out of doors on various types of targets.***1. Explain.—**

In the voice control methods the elevation is obtained by one of the processes given below:—

i. When the angle of sight to the target can be taken from a position which is within 6 ft. in height of the gun position, and which is not more than 150 yards distant from it.

Measure the angle of sight to the target by means of the director. For all practical purposes this can be taken as being the angle of sight from the gun position.

Correct the range given by the range-taker by the amount his instrument was in front of, or behind, the guns.

The elevation will be given to the guns as a range \pm the angle of sight or as a quadrant angle.

ii. When the angle of sight to the target cannot be taken from a position within 6 ft. in height of the gun position one of the following methods may be employed. Both entail measuring the angle of sight from the observation post to the target and to the gun position:—

(a) Using the range O.P. to target and the angle of sight to the target, obtain from the V.I. table or slide rule the height the target is above or below the O.P.

Obtain the distance O.P.—gun position by pacing, or estimation, and, using the angle of sight to the gun position, obtain from the V.I. table or slide rule the height the gun position is below or above the O.P.

A comparison of the heights of the gun position and target above or below the O.P. will give the height the target is above or below the gun position.

Convert this from the V.I. table or slide rule to an angle of sight.

Example:—

Angle of sight from O.P. to target—Depression 22'.

Angle of sight from O.P. to gun position—Depression 2° 20'.

Range O.P.—target, 1,700 yards.

Distance O.P.—gun position, 80 yards.

Range gun position—target 1,750 yards.

Target is below O.P.—11 yards. (The amount subtended by 22' at 1,700 yards.)

Gun position is below O.P.—3 yards. (The amount subtended by 2° 20' at 80 yards.)

Therefore target is below gun position 8 yards.

From V.I. table or slide rule angle of sight (8 yards at 1,750 yards) = depression 15'.

(b) Obtain the angle of sight gun position—target from the following formula and calculate the Q.A. as in sub-para. i, above:—

$$\left. \begin{array}{l} \text{Angle of sight} \\ \text{from gun position} \\ \text{in minutes} \end{array} \right\} = \frac{(a_1 \times GO) + (a_2 \times OT)}{GT}$$

Where T is the target, O the position of the director and G the gun position and where

a_1 is the angle of sight from G to O in minutes.

a_2 is the angle of sight from O to T in minutes.

a_1 and a_2 must be provided with the correct signs before being placed in the formula, *i.e.* plus for angles of elevation, minus for angles of depression.

Example:—

Angles of sight are measured by director.

To target—Depression 5'.

To pivot gun—Depression 3°.

The angle of sight from G to O is opposite in sign to that from O to G, and is therefore elevation 3°.

OT = 1,900 yards, OG = 150 yards, GT = 2,000 yards.

The required angle of sight in minutes

$$= \frac{180 \times 150 + (-5 \times 1,900)}{2,000}$$

$$= \frac{18 \times 15 - 5 \times 19}{20}$$

$$= \frac{270 - 95}{20} = +\frac{175}{20} = \text{approx. } 9' \text{ elevation.}$$

Angle of sight = 9' elevation.

2. The target may have a different range to each end, and possibly also a different angle of sight. In this case the elevation must be calculated for each end of the target, which will give the elevations for the flank guns. The difference between these two elevations divided by three (the number of

gun intervals) will give the increase or decrease in elevation required between adjacent guns.

For example :—

No. 1 gun. Range 1,500. A. of S. +30'.

No. 4 gun. Range 1,350. A. of S. Nil.

The elevations for remaining guns will be

No. 2. Range 1,450. A. of S. +20'.

No. 3. Range 1,400. A. of S. +10'.

3. In the application of the combined sight rule, when firing indirect, the fact that the guns are not concentrated inside the limits of the parallel zero lines entails fire being opened with all guns on the lowest of the elevations required according to range. A succession of lifts is then given until the highest of the required elevations has been reached.

NOTE.—In the case of an oblique target having a different range to each end, when a Q.A. is being used the lift in minutes will be taken from the mean range to the target on the lower elevation.

4. Targets with depth are engaged according to the general principles contained in Lesson 104 (the engagement of targets with depth—Direct fire).

LESSON 115.—CREST CLEARANCE

Instructor's Notes

Stores :—

Blackboard, range table, director, gun and tripod with dial sight.

Method of instruction :—

The procedure will be explained indoors. The squad will be practised with examples and the instructions completed out of doors on various types of targets.

1. Explain.

The initial responsibility for determining whether the bullets will clear the crest in front of the guns rests with the fire controller. He must ensure that, when he chooses the gun position, clearance exists for the target or targets he intends to engage.

It will not always be necessary or practicable to resort to measurement by instruments and calculation of crest clearance during the reconnaissance for the gun position. With practice it may often be possible to judge how far back the gun position can be situated without risk of the bullets striking the crest. If, however, the range is short and the crest steep, it will be

necessary to check the clearance as outlined below before the gun position is decided on and the guns are brought up.

The subsequent responsibility will rest with the N.C.O. in charge of the gun position. He must ensure that after the guns have been laid initially for direction and elevation, no gun is fired unless the bullets will clear.

Further, he must, at the first opportunity, ascertain the lowest quadrant angle at which the crest can be cleared and report it to the fire controller.

Calculations should always be made with reference to the highest point over which the guns may be called upon to fire.

The procedure for ascertaining the minimum quadrant angle either before or after the guns have occupied the position, and for checking whether the bullets will clear the crest after the guns have been given their initial line and elevation, is given below.

2. i. A crest up to 150 yards from the gun position.

In this case the axis of the bore and the trajectory can be taken as coincident as far as the top of the crest, *i.e.* the bullet has not had time to fall appreciably.

(a) To ascertain the minimum quadrant angle.

Procedure.

Set up a director at gun height and measure the angle of sight to the highest part of the crest. Add 15' to allow for bottom half of the cone, etc. Compare this angle with the quadrant angle to hit the target. If the latter is the same or greater, the crest will be cleared.

If the guns are in position, this may be done by laying a gun on the crest, using the tangent sight set at zero, and then record the angle on the gun as in Lesson 34 (b). This angle will be the angle of sight to the crest. To this add 15'.

(b) To ascertain after the guns have been laid for elevation and direction whether the crest is cleared.

Set the tangent sight at 400 yards. If the line of sight clears the crest the bullets will clear.

This will allow for the lower half of the cone and the fact that the line of sight with the sights at zero is some 3½ inches above the barrel.

ii. A crest more distant than 150 yards from the gun position.

(a) To ascertain the minimum quadrant angle.

Procedure.

Obtain the range to the crest by range-finder. Increase it by 5 per cent. Look up in the range table the tangent angle corresponding to this range, and the depth of the bottom half of the cone at this range.

Take the angle of sight to the highest point of the crest. This may be plus or minus.

Minimum quadrant angle required will be the sum of the above three angles.

(b) To ascertain whether the crest is cleared after the guns are laid for direction and elevation.

Add 200 yards to the range obtained by the range-finder to the crest, place the resultant range on the tangent sight, and see whether the line of sight clears. This 200 yards allows for 5 per cent. range-taking error in addition to lower half of the cone.

LESSON 116.—ANGLE OF SWITCH

Instructor's Notes

Stores:—

Blackboard, one gun and tripod, dial sight, aiming post, directors.

The subject matter will be given in the form of a lecture.

1. Explain:—

i. In each of the following diagrams:—

G=Pivot gun or gun nearest to director.

O=Position of director.

T=1st target.

G.T=Zero line on to 1st target.

X=Fresh target.

ii. It is not true to say that the angle of switch between T and X measured from O is for practical purposes equal to the angle of switch measured from G to bring G from GT to GX. The error may be so great that all four guns will miss the fresh target. The size of the error varies with the relationship of TOG and X to one another.

In every case it is necessary to find the angle TGX as accurately as possible.

(a) In very rare conditions it may be possible with a director mounted in the gun position to measure the angle TOX which obviously will be the same as the angle TGX.

(b) Sometimes O may be within the zero lines of the guns, either in front or behind.

From O measure angle TOX, convert that angle to yards at range OX. Convert those yards back to angle for GX. The answer will be angle TGX. (Angle of switch for G from T to X.)

e.g. Angle TOX = 8° at OX 1,500x = 210x.
210x at GX 1,600 = $7^\circ 30'$ = angle TGX.

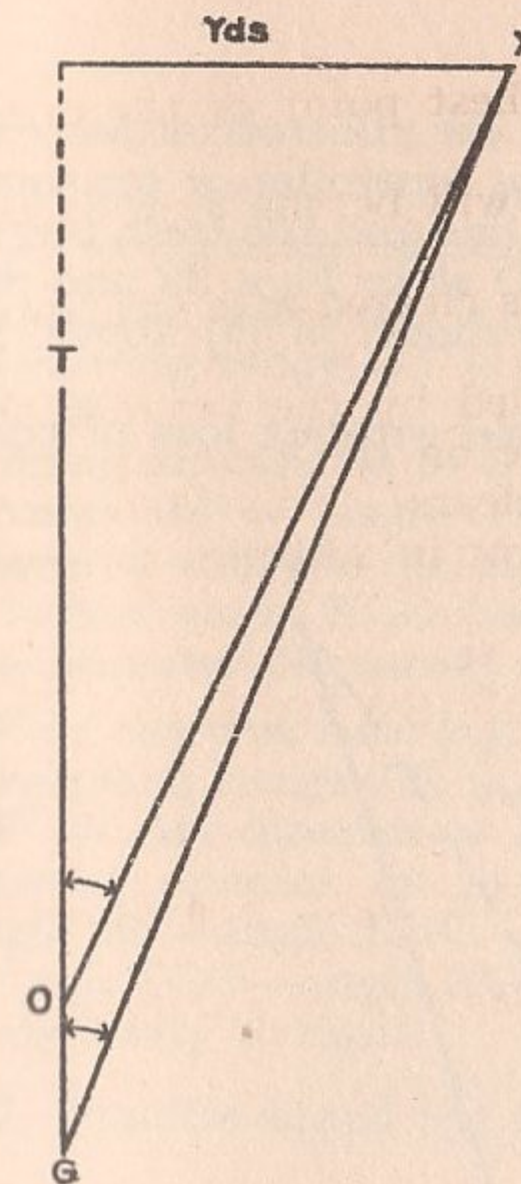


Fig. 33.

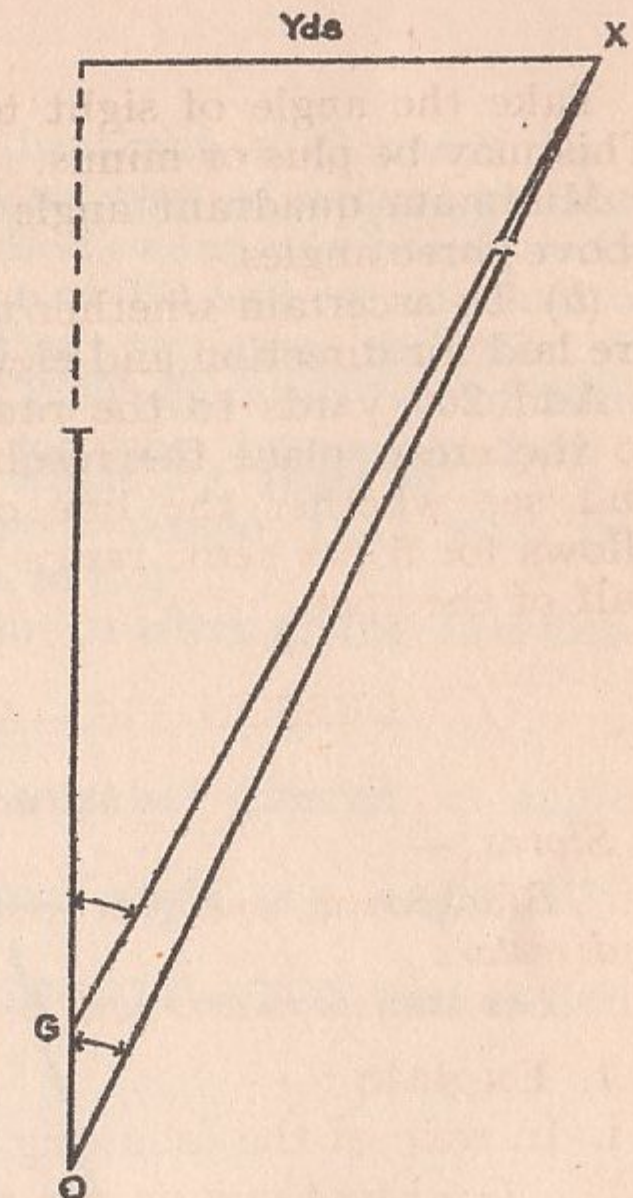


Fig. 34.

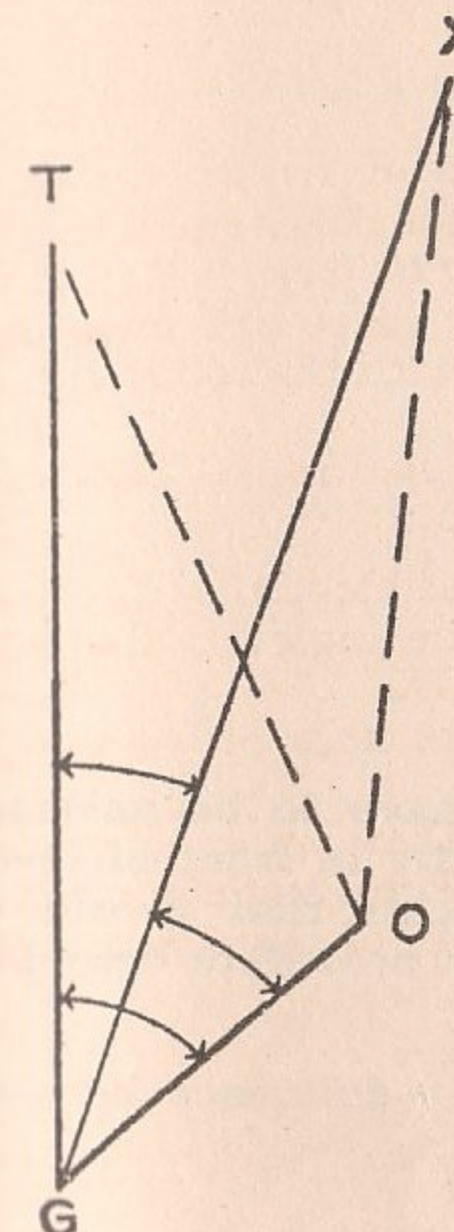


Fig. 35.

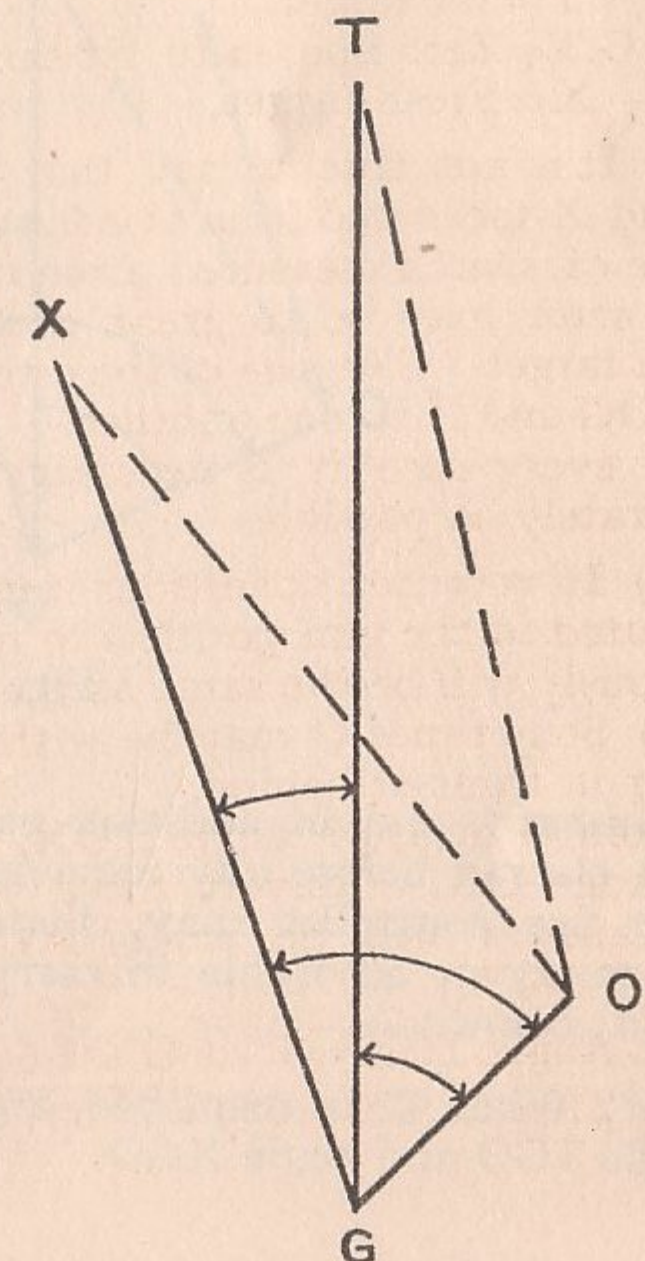


Fig. 36.

(c) When O is displaced, whether for control or for calculation it may be possible for the fire controller or for some other person who knows both the zero line and the fresh target to move to the line GT to a position O as in Figs. 33 and 34. He will then carry out the procedure shown in (b) above, in order to find the angle TGX.

Such movement may not be possible without loss of con-

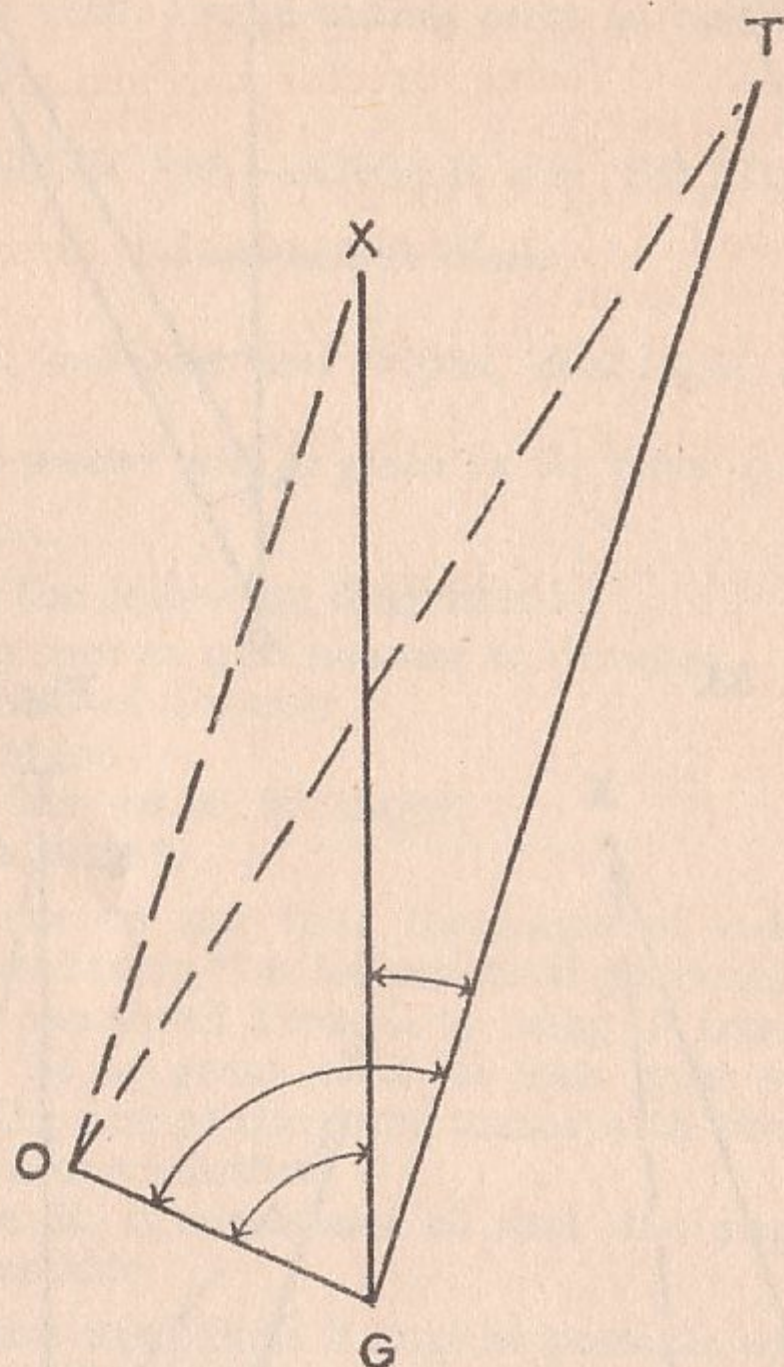


Fig. 37.

cealment; and in addition guns will have to be unloaded and cleared before any movement directly in front of them. The fire controller may, therefore, decide that it will be necessary or advisable to carry out the procedure described in (d) below:—

(d) When O is displaced, angle TGX = difference between angle TGO and angle XGO .

Example from Fig. 35.

To find angle TGO (using director as when giving zero line from director displaced):—

Find the true base (*e.g.* 96 yards).

Knowing range GT (*e.g.* 1,500 yards) set director at angle $176^\circ 20'$.

Swing director on to G and read angle (*e.g.* angle 35°).

Angle 35° = angle TGO . (Note:—Angle TGO may be measured with the dial sight of gun at G .)

To find angle XGO (using director as when giving direction from director displaced):—

Find the true base (*e.g.* 43 yards).

Knowing range GX (*e.g.* 1,800 yards) set director at angle $178^\circ 30'$, lay director on X .

Swing director on to G and read angle (*e.g.* angle 25°).

Angle 25° = angle XGO .

Angle TGO —angle XGO = $35^\circ - 25^\circ = 10^\circ = TGX$ and switch is obviously to right.

2. Practise squad out of doors.

SECTION 26.—NIGHT FIRING

1. This section contains the arrangements to be made for engaging a target at night. It should be noted that these arrangements can be applied to conditions of bad visibility such as fog, dust or smoke.

2. The simplest method of night firing is when the guns can be brought into position by day, laid, and aiming posts planted. If more than one target is to be engaged, it would be necessary to place the guns on zero lines. At dusk, aiming lamps will be put out. (See Lesson 71.)

If the target is not visible from the gun position, indirect means must be employed to lay the guns.

3. Before darkness falls, all data required to enable the various targets to be engaged must be obtained.

These include some or all of the following :—

The angles of sight and ranges to the various targets.

The angular width of the targets.

The angles of switch.

Data affecting any existing or possible safety problem.

It is essential that the magnetic bearing of the zero line should be recorded as a check.

4. When firing is carried out from positions behind the forward localities, special precautions, such as posting sentries or wiring the danger area, must be taken to ensure the safety of our own troops when passing near the gun position.

LESSON 117.—RECONNAISSANCE BY DAY (ONE TARGET ONLY)

Instructor's Notes

Stores :—

Gun pegs, direction pegs, zero posts and directors.

Method of instruction :—

A simple tactical situation will be defined and the procedure explained. The squad will practise putting out pegs both in front and in rear of the gun position.

1. Mark the position of each gun by a small post (gun peg).

Place a second post (direction peg) for each gun in direct alignment of the gun peg and the position on the target for the gun concerned.

Place a zero post accurately in line with and between the gun peg and direction peg.

Both direction peg and zero post can be put in either by using a director or by eye.

The direction peg should be about 30 yards from the gun peg and the zero post in such a position that it will be silhouetted against a lamp, held behind the direction peg.

To avoid exposing personnel in front of the gun position, it may often be desirable to place the direction pegs and zero posts in rear of the gun pegs. In this case it may be necessary to screen the aiming lamps from the front when giving direction to the guns.

2. When the guns are brought up the procedure is as described in section drill—night firing (Sec. 19).

LESSON 118.—RECONNAISSANCE BY DAY (TWO OR MORE TARGETS)

Instructor's Notes

Stores :—

As for Lesson 117, with the addition of slide rules and range tables.

Method of instruction :—

The instruction will be developed from Lesson 117, so as to include placing guns on parallel zero lines.

Explain.—

Here it is necessary to put out gun direction pegs and zero posts for each gun on parallel zero lines, so that the guns can be switched. The direction pegs and zero posts may be in front of or behind the gun pegs.

Gun pegs are put out for each gun. A zero line is selected and a direction peg and zero post for the pivot gun aligned on it.

Where a distant aiming point is available (Lesson 111) with a director measure the angle between the distant aiming point and the zero line for the pivot gun. Mount the director in turn over the remaining gun pegs, lay this angle off the aiming point and place the direction peg and zero post in this line.

Where no distant aiming point is available, the following method may be adopted. The procedure is described for two guns only, but can be extended to include four guns if required.

Put out gun pegs for each gun (G_1 , G_2) (Fig. 38).

Place a direction peg (P_1) and zero post (Z_1) on the zero line for the pivot gun, either in front of or behind the gun position.

Measure the distance between the gun pegs (G_1, G_2) either by pacing or with tape or string.

By means of the V.I. table or slide rule calculate the angle $G_1T_1G_2$, i.e. the angle subtended at the range G_1T_1 by the distance G_1G_2 .

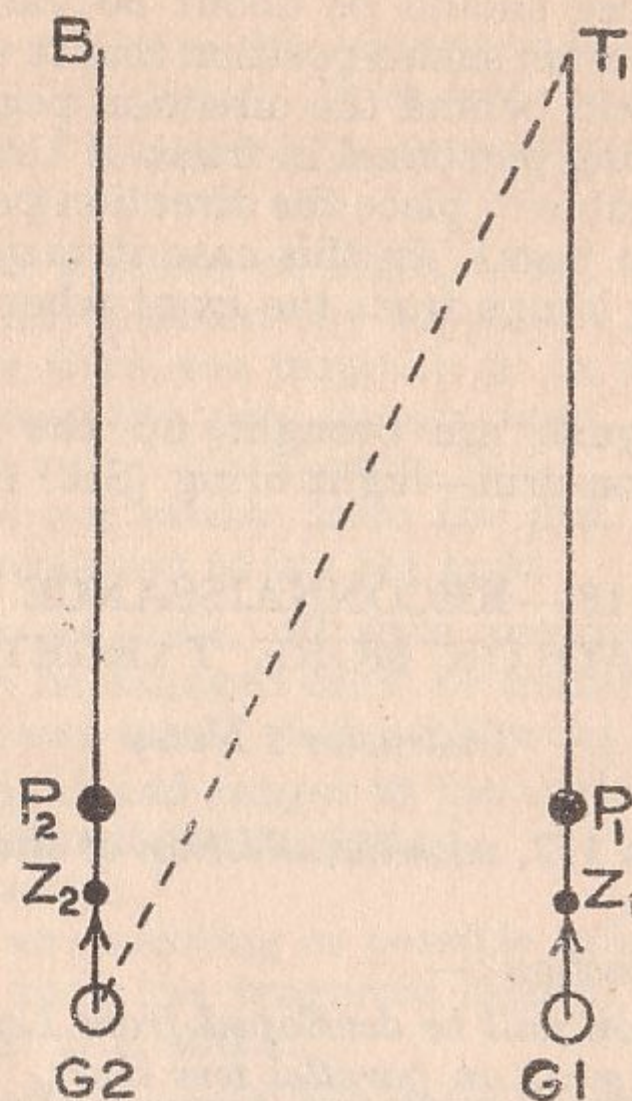


Fig. 38.

Set up the director over the other gun peg (G_2) and lay it on T_1 with the arrow at 0° . Lay off the angle found above right or left as required (left in case shown), and place a direction peg (P_2) and zero post (Z_2) on this line.

If more convenient, the angle T_1G_2B can be laid off by means of a slide rule or by any other means of measuring accurate lateral angles.

LESSON 119.—RECONNAISSANCE BY DAY (INDIRECT FIRE)

Instructor's Notes

Stores :—

As for Lesson 118.

Method of instruction :—

Instruction will be developed from Lesson 118 to include the observation post.

Explain.—

When the targets are not visible from the gun position to be occupied, but are visible from an observation post within voice control of the gun position, the following will be the procedure :—

Gun pegs are put out for each gun. Direction pegs and zero posts on parallel zero lines are then placed in position by any of the indirect means already described.

If the director or post method is employed, two directors should be used.

In the director method the second director is mounted over each gun peg in turn and lays off the angle measured by the other director for that gun. The direction peg and zero post are then put out on this line.

In the post method, one director will be mounted over the gun peg for the pivot gun, the other being mounted over each of the remaining gun pegs in turn.

LESSON 120.—RELIEF OF GUNS BY NIGHT

Instructor's Notes

Stores :—

Two or more guns and tripods, dial sights, gun pegs, direction pegs, zero posts, aiming lamps, aiming posts.

Method of instruction :—

Guns will be in position laid for direction and elevation.

The procedure of relief will be carried out in detail.

Where opportunity offers, from this lesson can be developed the full process of occupation and relief by two separate sections.

Explain.—

i. The collimator on the gun to be relieved will be zeroed. The angle to the aiming lamp will then be measured and handed over to the N.C.O. i/c the relieving gun.

ii. The N.C.O. i/c the relieving gun will supervise a gun peg being placed accurately under the socket of the gun to be relieved. To do this the gun and cross head will be removed.

iii. The gun to be relieved will then be removed ; the relieving gun being mounted accurately over the gun peg.

iv. The angle measured in (i) above will be set on the dial sight of the relieving gun, and the gun then tapped until the collimator is aligned on to the aiming lamp of the section being relieved. The relieving gun is then laid for direction.

v. When both guns in the relieving section are laid for direction, this aiming lamp will be removed. The relieving section will then put out its own aiming lamp, the further procedure being as in section drill.

Night firing (Sec. 19).

LESSON 121.—WHEN THE GUN POSITION CANNOT BE REACHED BY DAY

Instructor's Notes

Stores :—

Compass, gun and direction pegs, zero posts, one (or more) guns, tripods and dial sights.

Method of instruction :—

The class will practise laying out compass lines from gun pegs. The measuring of direction and elevation from the map should not be practised until Lesson 122 is reached. The class will then practise as in (ii).

Explain.—

i. When a map is available.

The true (or grid) bearing from the pivot gun to the target or zero line is measured from the map and converted to compass bearing; using a compass, gun pegs, direction pegs and zero posts for each gun are put out on this bearing (Lesson 122). The guns are then mounted over the gun pegs.

If desired, a gun peg, direction peg, and zero post for the pivot gun only can be put out by means of the compass. The guns are mounted, the pivot gun being mounted over its gun peg and given direction. The remaining guns are then placed on parallel lines by the post method (Lesson 110). The point of aim for each gun must be illuminated.

When using either of the above methods great accuracy cannot be expected.

ii. When no map is available.

If circumstances allow of a light being shown on the spot where it is desired that the fire should fall, arrangements can be made to fire on a fixed line at short range with fair accuracy.

The procedure is described in Lesson 131.

SECTION 27 MAP SHOOTING

1. Accurate shooting from the map is only possible when a map scale 1/25,000 or larger is available. Where accuracy is not essential, for example, for the engagement of areas well removed from the position of our own troops, maps of smaller scale should not be ignored, but it should be noted that the detail on such maps is not usually "surveyed in."

2. The principle of map shooting is that all calculations, both for direction and elevation, are made from the map. The method has certain definite advantages, namely :—

- i. No observation post is necessary.
- ii. Preparations to open fire can be made before the actual targets have been located.
- iii. Targets can be engaged which cannot be seen by ground observation.

3. The method entails fixing the position of the pivot gun on the map, and by various means laying out a zero line for each gun. These processes must be carried out in daylight, though the guns themselves need not be brought into action until after dark. Therefore orders for a map shoot to be carried out at night must reach the platoons concerned in sufficient time before dark.

4. The pivot gun can be fixed on the map either :—

- i. By comparing the detail on the ground with the detail on the map; or, if this is not possible;
- ii. By resection. (*See Manual of Map Reading, Photo Reading and Field Sketching, 1929, Sec. 56.*)

Where time permits, greater accuracy is ensured by employing one method and checking with another.

It may be possible to obtain the aid of a survey unit where a very accurate location is necessary.

Oblique air photographs may be helpful.

LESSON 122.—SHOOTING FROM THE MAP

Instructor's Notes

Stores :—

Map (minimum scale 1/25,000), protractor, compass, gun and direction pegs, zero posts, director.

Method of instruction :—

The class will be instructed in measuring angles and bearings on the map and will then work out problems of elevation and

distribution. Indoor work should conclude with the construction of a fighting map (Plate 27) on which problems should be set.

The class will practice out of doors the locating of the pivot gun both by local detail and resection.

Explain.

i. Direction.

A zero line is chosen in the centre of the target area, or, if the targets are not known, in the most suitable direction.

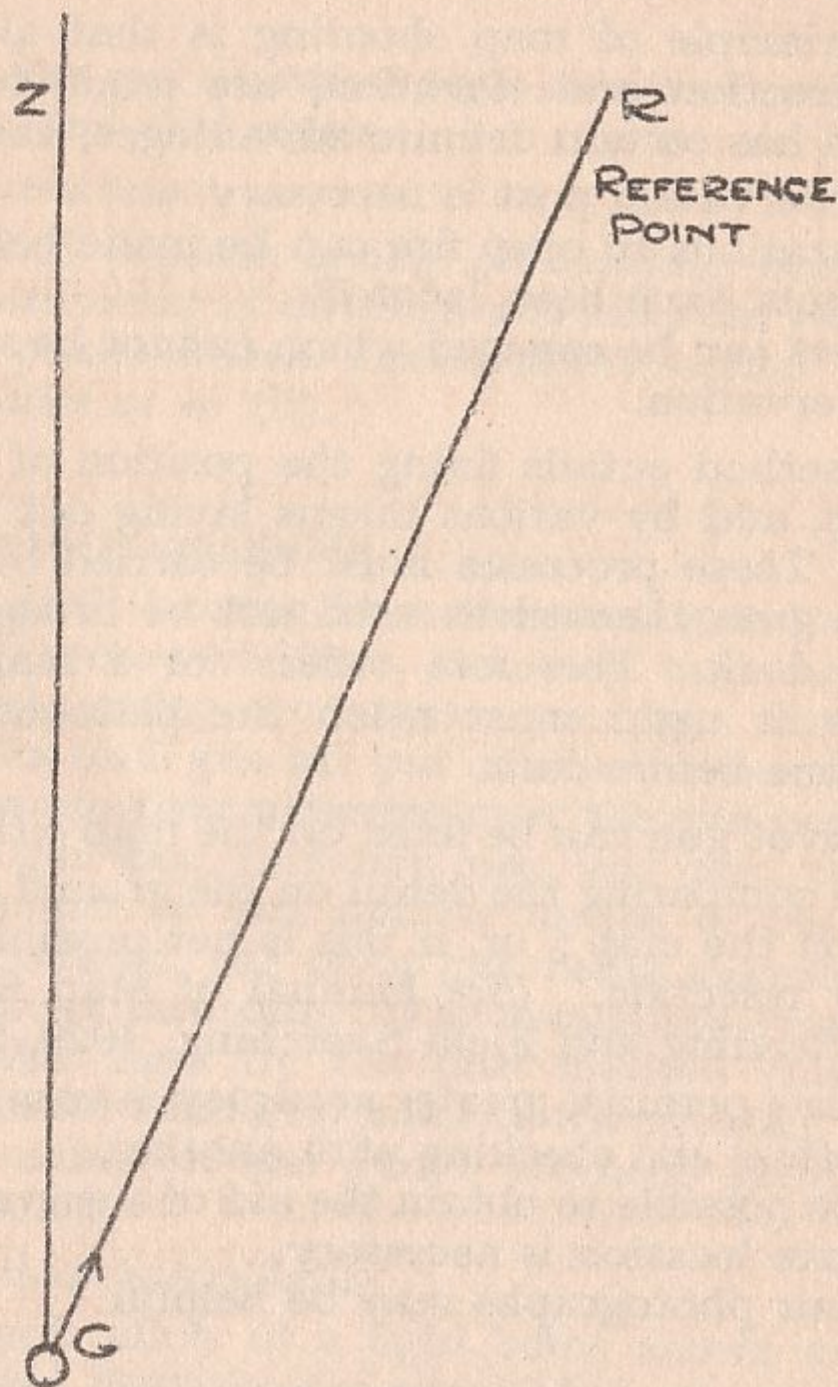


Fig. 39.

Two methods may be employed for placing the guns on their zero lines :—

- (a) By means of a reference point.
- (b) By compass.
- (a) By reference point.

A reference point which is both marked on the map and visible from the pivot gun is selected. (See Fig. 39.)

The zero line of the pivot gun is drawn on the map (GZ).

The line joining the pivot gun to the reference point is also drawn in (GR).

The angle RGZ is measured with a protractor.

If the guns are in position :—

This angle is set on the dial sight of the pivot gun, which is then tapped over until the dial sight is laid on the reference point.

The remaining guns are placed parallel to it by the most suitable method.

If the guns are not in position :—

Mark the point G with a gun peg.

Mount a director centrally over it and swing through the angle RGZ.

Place a direction peg and zero post on the line GZ a suitable distance from the gun peg.

Mark the positions for the remaining three guns with gun pegs.

Place direction pegs and zero posts for each gun on lines parallel to GZ, by any of the methods described in Lessons 108, 110, 111.

(b) By compass.

The magnetic bearing of the target from the pivot gun must be found.

To do this—

Draw a line on the map along the zero line of the pivot gun.

Using the protractor, measure the bearing this line makes with a grid north and south line.

This is the grid bearing of the zero line of the pivot gun.

Add the magnetic variation of the compass from grid north. The result is the magnetic bearing of the zero line from the pivot gun. This applies to places where the magnetic variation is west. If the variation is east, subtract instead of add.

The variation of any compass used must be determined for the particular locality, and should be constantly checked.

To lay the pivot gun on the magnetic bearing so obtained.

Place a post in the gun position, and place the compass on the top of the post. Rotate the compass until the card reads the required bearing.

Align a direction post on this bearing, using the hair line on the compass.

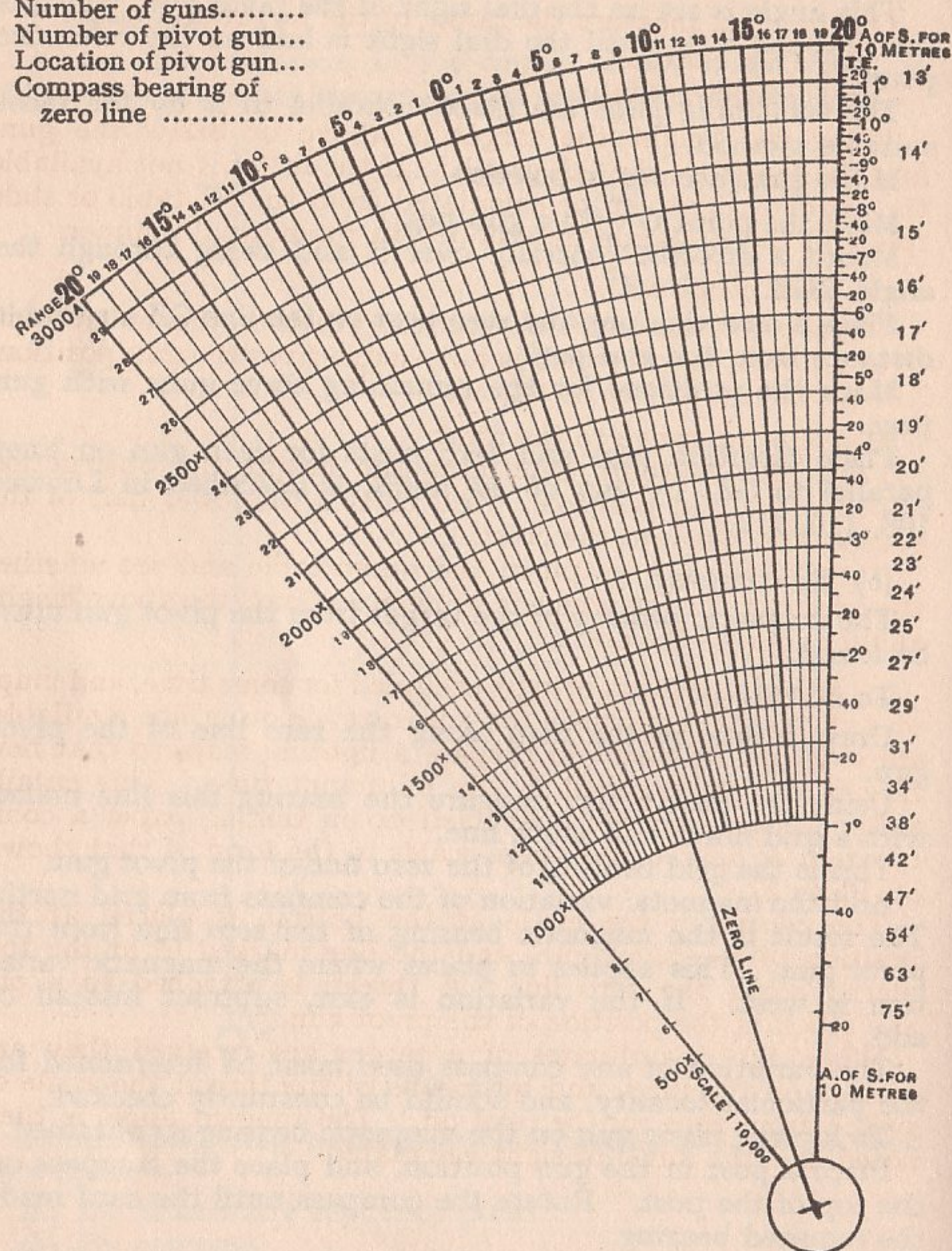
Proceed as described under the reference point method above, according to whether the guns are in position or not.

PLATE 27

FIGHTING MAP—PLATOON OR SECTION

Ref. Map.....

Number of guns.....
 Number of pivot gun...
 Location of pivot gun...
 Compass bearing of
 zero line



Date.....

Platoon Commander

ii. *Distribution.*

On the map, join the pivot gun to the two ends of the target. Measure with a protractor the angle thus formed at the pivot gun. Taking this as the angular width of the target, proceed as in Lesson 113.

iii. *Elevation.*

On the map, measure the range to the target and note :—

- (a) Gun contour.
- (b) Target contour.

Using the height the target is above or below the gun, find the QA from the QA graph. If the latter is not available the angle of sight can be calculated from the VI table or slide rule and the elevation determined in the normal manner.

iv. *Crest clearance.*

It may be necessary to ascertain whether the bullets will clear an obstruction which is not visible from the gun position. The procedure will be as follows :—

Measure the range to the crest.

From the contours determine the height the obstruction is above the gun position. Add to this the lower half of the cone at the range to the crest.

Turn to the QA graph in the range table and see whether the curve for the QA which is being used clears the above height at the range to the crest.

v. When a position is to be occupied for some time, and maps of sufficiently large scale for accurate shooting are available, steps should be taken to prepare a fighting map, so that new targets can be engaged in the minimum time. This entails either drawing on the map itself or on tracing paper a combination of degree and range scales in the form of that shown on Plate 27.

The centre of the circle at the bottom is placed at the position of the pivot gun, and the line marked 0° at the top placed along the zero line. A thread is attached to a pin and stuck in the position of the pivot gun.

When the co-ordinates of a target are received they are plotted on the map, and by means of the thread the angle of sight from zero can be read off. The tangent angle is then noted and the angle of sight calculated.

The range $G_1 T_2$ and the angle $T_2 G_1 O$ are obtained from the plotter.

The angle OG_1T_1 has already been obtained, and it can be seen that the angular width of the target from the gun position $\text{T}_1\text{G}_1\text{T}_2 = \text{T}_2\text{G}_1\text{O} - \text{T}_1\text{G}_1\text{O}$.

The angle of distribution can then be calculated in the normal manner. (Lesson 113.)

If T_2 is at a different range or has a different angle of sight to T_1 , it will be necessary to calculate the quadrant elevation for each gun as in Lesson 114.

3. Crest clearance.

If there is a crest X (Fig. 42), invisible from the guns, and there is a doubt as to whether the bullets will clear, the procedure is as follows:—

Measure the angle XOG_1 , and angle of sight from O to X.

Obtain from range-taker range OX.

As before, solve the triangle XOG_1 to obtain G_1X and angle OG_1X . By comparison of the angles OG_1X , OG_1T_1 and OG_1T_2 , it can be determined whether the obstruction is in the line of fire.

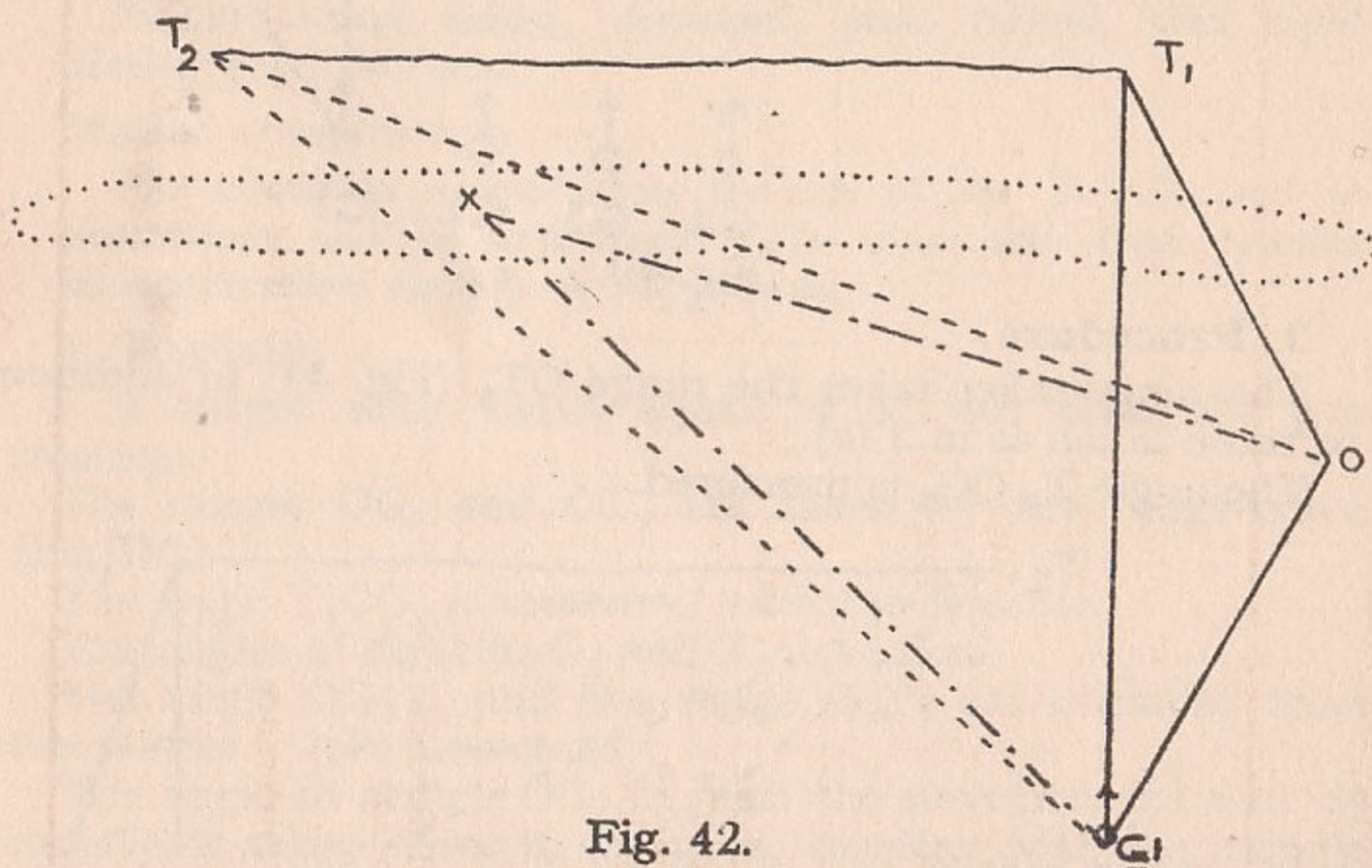


Fig. 42.

If this is the case, ascertain the corrected angle of sight from G to X (Lesson 114) and work out the minimum quadrant angle (Lesson 115) to clear X. Compare this angle with the lowest quadrant angle used to engage T_1 — T_2 .

4. A specimen form to simplify the booking of the data and the subsequent calculations is given below. The data obtained by measurement is underlined. In practise, all data should be obtained before calculation is commenced.

				Min.	Yards
OG	=	Angle of sight O to G	=	G	above below
OT ₁	=	T ₁ OG	=	T ₁	above below
OT ₂	=	T ₂ OG	=	T ₂	above below
OX	=	XOG	=	X	above below
Wind					
GT ₁	=	T ₁ above below	Yards	Min.	Range
GT ₂	=	T ₂ above below			
Angle of switch for T ₁					
Angle of switch for T ₂					
Width of target (difference =					
Width of gun frontage =					
Difference					
Divided by 3 = Angle of distribution =					
XGO	=	X	above G	Minimum QA	=
GX	=	X	below		

SECTION 29.—FIRE DIRECTION AND CONTROL CHARTS

1. For the conduct of programme shoots, when fire is required at varying periods on one or more targets, it will generally be preferable to issue charts for the direction and control of fire. This will usually apply to shooting off the map and to firing by night; for example, in the provision of covering fire for a dawn attack, harassing fire, counter-preparation, etc.

2. **Fire direction charts** will be prepared by the M.G. company commander, with the object of allotting tasks to individual platoons, or, occasionally, sections. A suitable form is shown on page 85.

3. **Fire control charts** are made up by platoon commanders, one for each gun, and are interpreted by a N.C.O. at each gun. They are prepared from data obtained from the fire direction chart, if issued, and by measurement.

The chart contains the actual detail of switches, timing and rates of fire, and the elevation and number of taps right and left to be employed for each target. A suitable form is shown on page 86.

When firing indirect by day, it will often be advantageous to prepare a simplified form of chart for use at the guns.

LESSON 124.—PREPARATION OF CHARTS

Instructor's Notes

Stores :—

Map (1/25,000 or larger scale).

Method of instruction :—

Officers will be instructed in the preparation of both types of chart, both from detail on the map (indoor work) and from reconnaissance on the ground (outdoor work).

N.C.Os. will study only the preparation of fire control charts. They will be given the fire direction chart and instructed in compiling the fire control chart—both from detail on the map and on the ground.

1. Explain.

The angle of deviation from zero of any target is the actual deflection from the zero line to bring the gun on to its correct

position on that target. In the case of a platoon it is formed by combining the angle of switch with the angle of distribution, if any, or its correct multiple. (See Fig. 43.)

In the case of a section, it is formed by combining the angle of switch from zero lines with the angle necessary to bring each gun a quarter of the way in from its own flank of the target.

When dealing with targets with width equal to or less than the gun frontage, guns are kept on parallel lines.

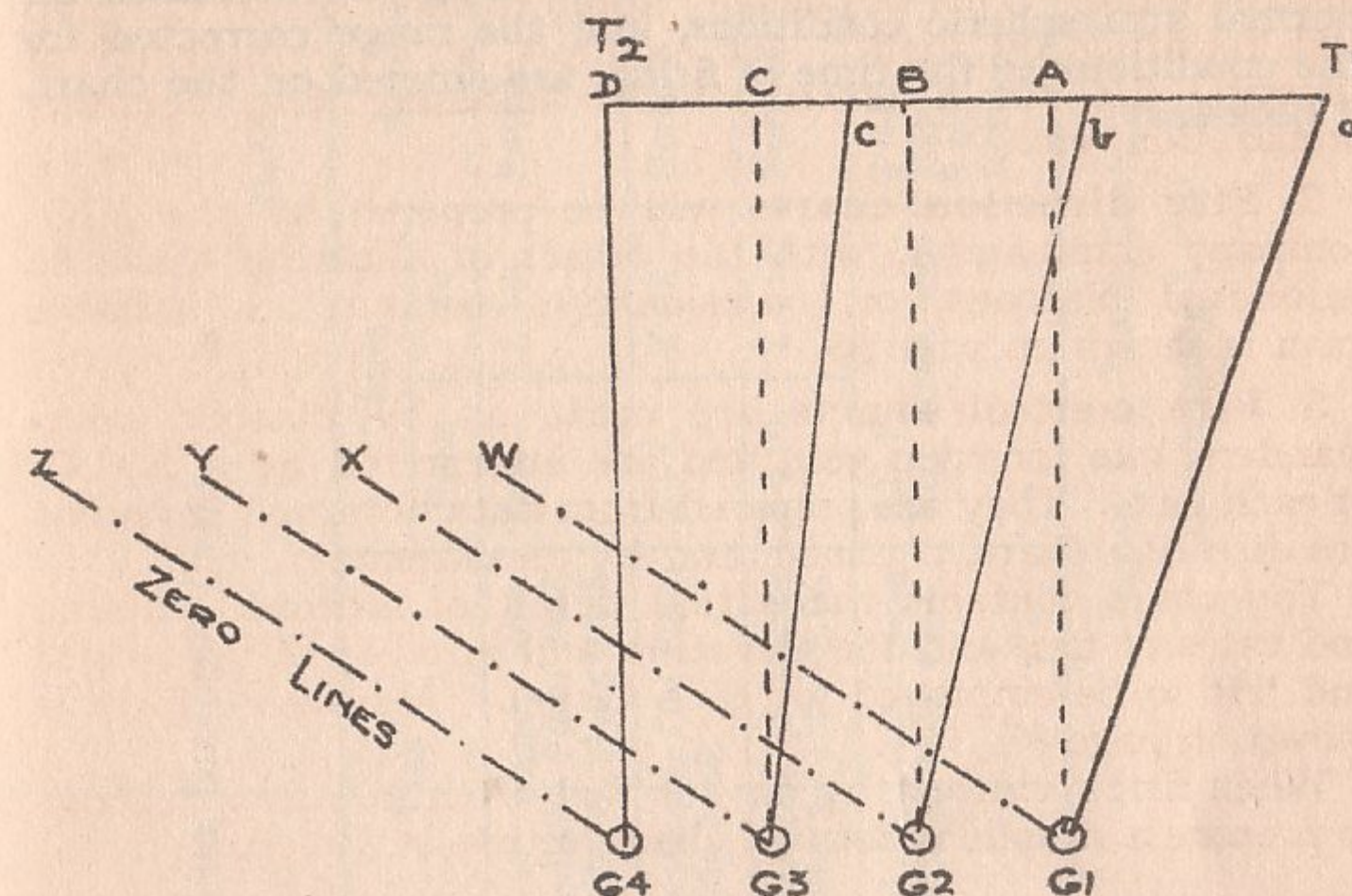


Fig. 43.

Angle ZG^4T^2 = Angle of switch.

CG^3c = " distribution.

cG^3Y = " deviation from zero, No. 3 gun.

bG^2X = " " " " No. 2 gun.

aG^1W = " " " " No. 1 gun.

Example.—

The angle of switch for a certain target is Right 11° , the angle of distribution is 30 minutes. No. 4 is the pivot gun. It is required to find the angle of deviation from zero for No. 1 gun.

No. 1 gun has to be swung to the right through the angle of switch = Right 11° , and also (still in the same direction) through three times the angle of distribution = $3 \times 30' = 1^\circ 30'$; the angle of deviation from zero is therefore Right $12^\circ 30'$ for this particular gun and target.

If the switch had been *left* 11° , the angle of deviation from zero would have been Left $9^{\circ} 30'$.

2. When zero lines are laid out before the targets have been decided, it may occur that the zero line originally chosen is not the most suitable for the targets. In this case the zero line should be corrected by an angle of switch to a new and suitable zero line, and the fire control chart made out with reference to the latter.

3. It should be noted that both the range as calculated for normal atmospheric conditions, and the range corrected for the conditions at the time of firing, are entered on the chart, if necessary.

FIRE DIRECTION CHART

Unit and Role.	Ref.	Map	Date	Times		Rate of fire.	Remarks.
				From	To		
No. 1 Platoon (Supporting guns).		Track junction W. Corner of Robin Hood Ball 544666.		Zero	Z + 4.	Rapid.	
		Pivot gun laid on right end of Old Farm Clump.		Z + 4.	Z + 8.	Normal.	
				Z + 10.	Z + 14.	Normal.	
		45x frontage.		S.D.F. Red, green, red.		2 min. Rapid. 3 min. Normal.	

Signed, F. J. Blank, Capt.,
Commanding A Coy.

FIRE CONTROL CHART
No. 1 PLATOON ROLE

No. 4 Gun.

Magnetic bearing of zero line 3°.

N.C.O. i/c Gun—Corpl. Round.
Angle of switch to corrected zero line—Nil.

Task	Clock Time		Zero Time		Angle of deviation from zero	Normal Range or Q.A.	Corrected Range or Q.A.	Angle of sight	Right and Left—Taps	Rate of fire	Remarks
	From	To	From	To							
1.			Zero.	Z+4	R. 7° 10'.	1750x. Lift 100x.		-40'.	3	Rapid.	Fire one minute on each elevation alternately.
2.			Z+4	Z+8	L. 1° 20°	2150 Lift 100x.		-25'.	1	Normal.	Do.
3.			Z+10	Z+14	L. 13° 30'.	1950x Lift 100x.		-20'.	3	Normal.	Do.
Fixed Line.	S.D.F. Red, Green, Red.				R. 2° 50'.	2100		-15'.	3	2 min. Rapid. 3 min. Normal.	

Signed, G. Smith, Lieut.

Commanding No. 1 Platoon.

Date.....

SECTION 30.—EXAMPLES OF INDIRECT FIRE ORDERS

1. Point target, or target not wider than gun frontage. Range obtained by range-finder 1,600 yards. Angle of sight plus 30'. Wind 30 m.p.h. Rear. Director method.

Fire controller.
Zero lines.

No. 1—Right—Two one degrees one owe minutes.

No. 2—Right—Nine degrees.

No. 3—Left—Seven degrees four owe minutes.

No. 4—Left—One nine degrees.

All—Fifteen fifty plus two owe minutes.

Load.

Right and left—One tap.

Rapid fire.

Stop.

All up—One hundred.

Go on.

N.C.O. i/c gun position.

Reports "Guns ready to load".

2. Target with width.

Range obtained by range-finder 1,400 yards. Target width—6°. Angle of sight plus 50'. Wind 20 m.p.h. from half right—head. Post method. No. 1 Gun—Pivot gun.

Fire controller.

N.C.O. i/c gun position.

Zero lines.

No. 4—Left—Eight seven degrees two owe minutes.

No. 3—Left—Eight four degrees.

No. 2—Left—Eight two degrees five owe minutes.

Reports—"Guns on zero lines".

All—Fourteen hundred plus five five minutes.

Reports—"Guns ready to load".

Load.

Distribution.

No. 1—Nil.

No. 2—Left—One degree two owe minutes.

No. 3—Left—Two degrees five owe minutes.

No. 4—Left—Four degrees one owe minutes.

Right and Left—Four taps.

Wind—Right three owe minutes.

Fire.

3. Oblique target having the same range to each end, by range-finder. Range 1,750 yards. Angle of sight to right end plus 30', to left end nil.

Angular width 1° (less than gun frontage).

Wind—nil.

Director method.

Fire controller.

Zero lines.

No. 1—Right—Two two degrees one owe minutes.

No. 2—Right—One owe degrees.

No. 3—Left—Six degrees four owe minutes.

No. 4—Left—One eight degrees.

All—Seventeen hundred.

No. 1—Plus three owe minutes.

No. 2—Plus two owe minutes.

No. 3—Plus one owe minutes.

No. 4—Nil.

Load.

Right and Left one tap.

Rapid fire.

Stop.

All up one hundred.

Go on.

4. Oblique target, range to right end 1,600 yards, range to left end 1,450 yards, both by range-finder.

Angle of sight to right end plus 20', and to left end minus 10'.

Target width 3° 10'.

N.C.O. i/c gun position.

Reports—"Guns ready to load".

Wind 30 m.p.h. at right angles from the left.

D.A.P. and Post method. No. 1 Gun—Pivot gun.

Fire controller.

N.C.O. i/c gun position.

Zero lines.

All—Left eight seven degrees two owe minutes.

Reports—"Guns on zero lines".

No. 1—Fifteen fifty plus two owe minutes.

No. 2—Fifteen hundred plus one owe minutes.

No. 3—Fourteen fifty nil.

No. 4—Fourteen hundred minus one owe minutes.

Reports "Guns ready to load".

Load.

Distribution.

No. 1—Nil.

No. 2—Left three owe minutes.

No. 3—Left—One degree

No. 4—Left—One degree three owe minutes.

Right and Left two taps.

Wind—Left—One degree one owe minutes.

Fire.

Stop.

All up one hundred.

Go on.

5. Oblique target.

Range to right end 1,550, to left end 1,450, both by range-finder.

Angle of sight to right end plus 40' and to left end plus 10

Angular width 1° 30' (less than gun frontage).

Wind—Nil.

Director method.

Fire controller.

Zero lines.

No. 1—Right—One six eight degrees two owe minutes.

No. 2—Right—One seven five degrees three owe minutes.

N.C.O. i/c gun position.

No. 3—Left—One seven seven degrees.
 No. 4—Left—One seven owe degrees one owe minutes.
 No. 1—Fifteen fifty plus four owe minutes.
 No. 2—Fifteen hundred plus three owe minutes.
 No. 3—Fifteen hundred plus two owe minutes.
 No. 4—Fourteen fifty plus one owe minutes.

Load.
 Right and Left—One tap.
 Rapid fire.

NOTE.—As alternative method of working out the elevation is as follows :—

Elevation.
 No. 1—Three degrees five minutes.
 No. 2—Two degrees five owe minutes.
 No. 3—Two degrees three owe minutes.
 No. 4—Two degrees one five minutes.

6. Area target.

Range to near end 1,650 yards, to far end 1,750 yards, both by range-finder.

Angle of sight to near end plus 13' and to far end plus 21'.

Angular width of target 4°.

Wind Nil.

Director method.

Fire controller.

Zero lines.

No. 1—Right—One nine degrees two owe minutes.

No. 2—Right—Seven degrees three owe minutes.

No. 3—Left—Six degrees five owe minutes.

No. 4—Left—One eight degrees two owe minutes.

Elevation—All two degrees five owe minutes.

Reports—"Guns ready to load".

N.C.O. i/c gun position.

Reports—"Guns ready to load".

Load.

Distribution.

No. 1 Nil.

No. 2—Left—Five owe minutes.

No. 3—Left—One degree four owe minutes.

No. 4—Left—Two degrees three owe minutes.

Right and Left three taps.

Fire.

Stop.

All up two five minutes.

Go on.

Stop.

All up three owe minutes.

Go on.

SECTION 31.—FLANKING AND OVERHEAD FIRE

1. The provision of supporting fire to our own troops is the main tactical role of the machine gun. The safety of the troops to whom such support is being given must be the first consideration of the machine gun commander.

2. Supporting fire can be provided either from the flank of a line of advance or defended locality or by overhead fire, that is, when the trajectory passes over the heads of our own troops. Where possible, flanking fire positions should be sought, not only because of the greater fire effect generally obtained from the beaten zone in enfilade, but also because fire from a flank can be put down with safety considerably closer to the troops being supported than can overhead fire. Before the occupation of a position for the purpose of overhead fire it is necessary to determine that such fire will be safe to our own troops. This increases the time required for the guns to be brought into action.

3. In order that the safety of the troops may be ensured, it is essential that their position or movements should be observed by or known to the fire controller.

In defence, this should not present any serious difficulty. In attack, the possibility of observing the movements of our own troops will depend on various factors, *e.g.* the nature of the ground (whether open, close, flat or hilly), obstructions to the field of view, bad visibility, smoke screens, etc. Since such observation can hardly be assured, it is evident that considerable caution will have to be exercised.

4. Apart from the above considerations, the machine gun, by reason of its stable mounting and the close grouping of its fire, is well suited to carry out flanking and overhead fire with safety to our own troops.

5. Flanking and overhead fire are governed by definite rules, which are contained in the following sections.

In solving any problem in connection with the safety of our own troops, the worst possible case must be taken as a basis for applying the rule.

LESSON 125.—FLANKING FIRE

Instructor's Notes

Stores :—

Sand model, slide rule and field glasses.

Method of instruction :—

The application of the rules will be explained on the model and the class will then practise on the ground.

1. Explain the following are the rules for flanking fire :—

The diagrams referred to in Plate 28 illustrate examples in defence and attack.

i. The line of fire must not be closer than 3° to the line joining the gun and the flank of our own troops.

Defence, A represents the flank of our own troops and GB the line of fire. For safety, the angle AGB must be 3° or greater.

Attack, GB is the line of fire to engage a target. If our riflemen are advancing in the direction shown, as soon as any man reaches the line GC, fire must cease.

ii. When firing at ranges up to and including 1,100 yds. the 3° limit extends up to a point 500 yds. beyond the point of aim. When firing at ranges over 1,100 yds. the 3° limit extends up to 400 yds. beyond the point of aim.

If C in both diagrams represent a point 3° from the far end of the beaten zone, our own troops, to be safe, must not cross the line GC at any point.

iii. This type of fire must not be attempted if the position of our own troops in the vicinity of the danger area is unknown.

As already pointed out, this entails either observation of our own troops or a timed programme, based on a rate of advance which must not be exceeded by the infantry companies concerned.

iv. Arrangements must be made to prevent tapping inside the 3° limit.

v. Careful allowance must be made for side winds.

For example, if in Defence, a wind was blowing from the left requiring an allowance of L 40', it would be necessary to place B 40 minutes to the left of its present position, or, in other words, increase the safety allowance to $3^\circ 40'$.

2. The lateral allowance of 3° covers :—

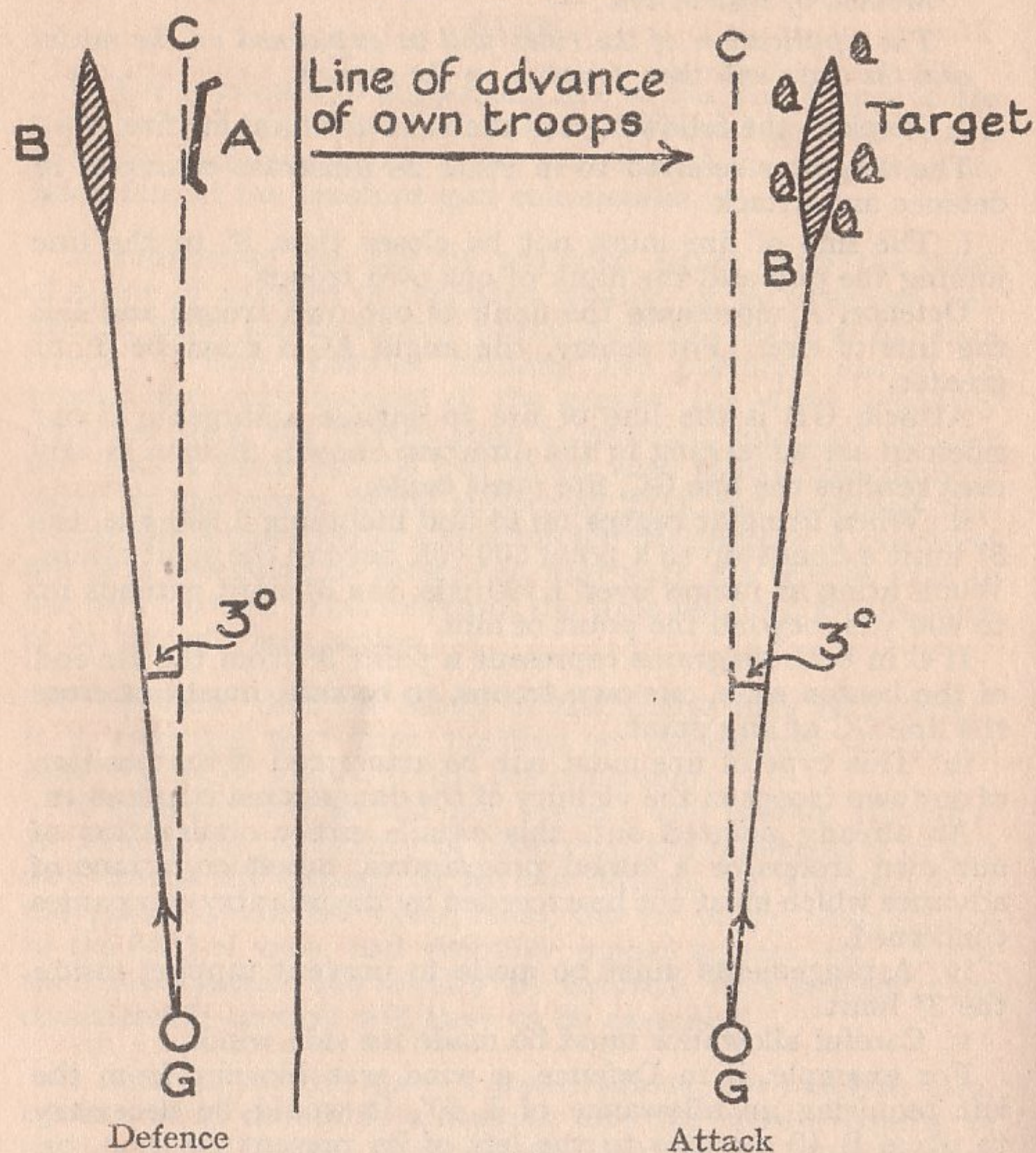
i. Minor inaccuracies in aiming, tapping, and in estimation of the strength of side winds.

ii. Movement of the tripod settling in during the first burst of fire, etc.

iii. Half the width of the beaten zone.

PLATE 28

FLANKING FIRE



A is a rifle locality.
B is a fixed line to it.
G is the gun line.

B is the target.
G is the gun line.

LESSON 126.—OVERHEAD FIRE (THEORY)

*Instructor's Notes**Stores:—*

Blackboard, slide rule, range table and field glasses.

Method of instruction:—

The theory contained in this Lesson will be explained and the class will work out simple problems on the safety angle. It will be made clear that these problems are in practice solved on the slide rule (Lesson 127).

1. Explain.*Rules for overhead fire.*

- i. Ranges to **our own troops** must be known to within 5 per cent., *i.e.* taken by range-finder, or from a map of not less scale than 1/25,000.
- ii. Fire must not be delivered over the heads of our own troops when the range to **those troops** exceeds 2,000 yards.
- iii. It must be ensured that the bullets pass at a certain minimum height above the heads of the troops being fired over.
- iv. Barrels and tripods must be in good order.

2. Clearance and minimum clearances.

i. "Clearance" at any point is the vertical height of the centre shot of the cone above that point. In accordance with rule iii. in para. 3, above, the minimum clearance for every range to our own troops has been calculated, and is laid down on pp. 2 and 3, range table. In these calculations allowances have been made with a sufficient safety margin on account of:—

- (a) Permissible errors in range-taking (up to 5 per cent).
- (b) Normal climatic variations.
- (c) Errors in sighting of guns and dial sight adjustment.
- (d) Movement of the tripod in settling in during the first burst of fire, etc.
- (e) The depth of the lowest shot of the cone below the centre shot.

ii. Influence of ground.

In Fig. 44, the cone at C is clearing troops at Z owing to two distinct factors:—

- (a) The natural curve of the trajectory above its line of sight.
- (b) The fact that the troops at Z are below the line of sight to the target.

In Fig. 45, the cone at C is clearing troops at Z on account of the curve of the trajectory only. The problem to be solved

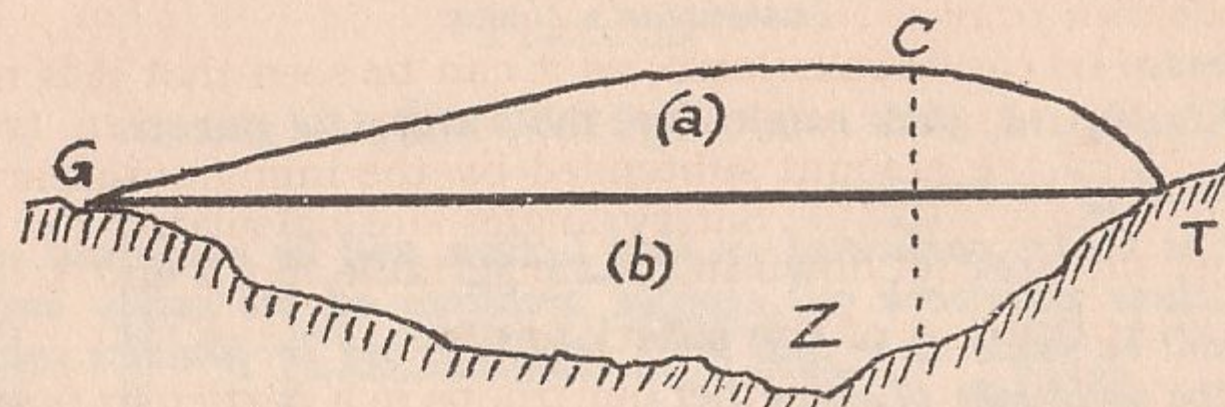


Fig. 44.

in Figs. 44 and 45, before overhead fire can be opened, is whether the cone will clear the point Z by the minimum safety clearance.

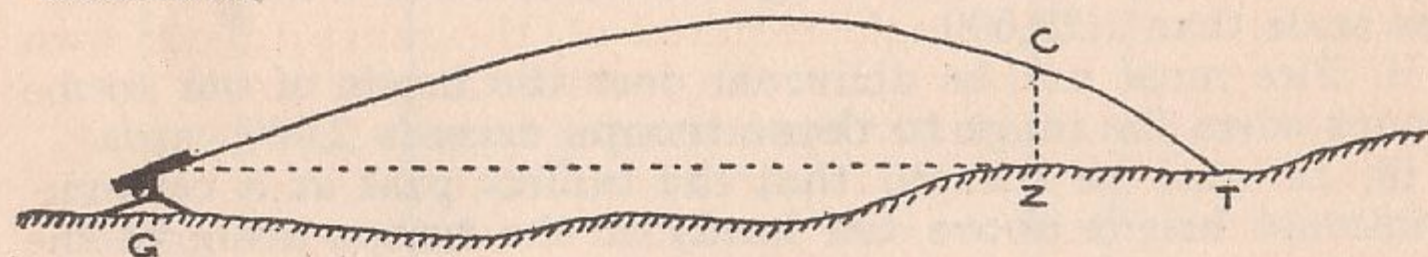


Fig. 45.

3. The safety angle.

The minimum clearance can also be expressed as an angle. Consider Fig. 46.

G is the gun.

GX the axis of the bore.

SZ the minimum clearance for our troops at Z.

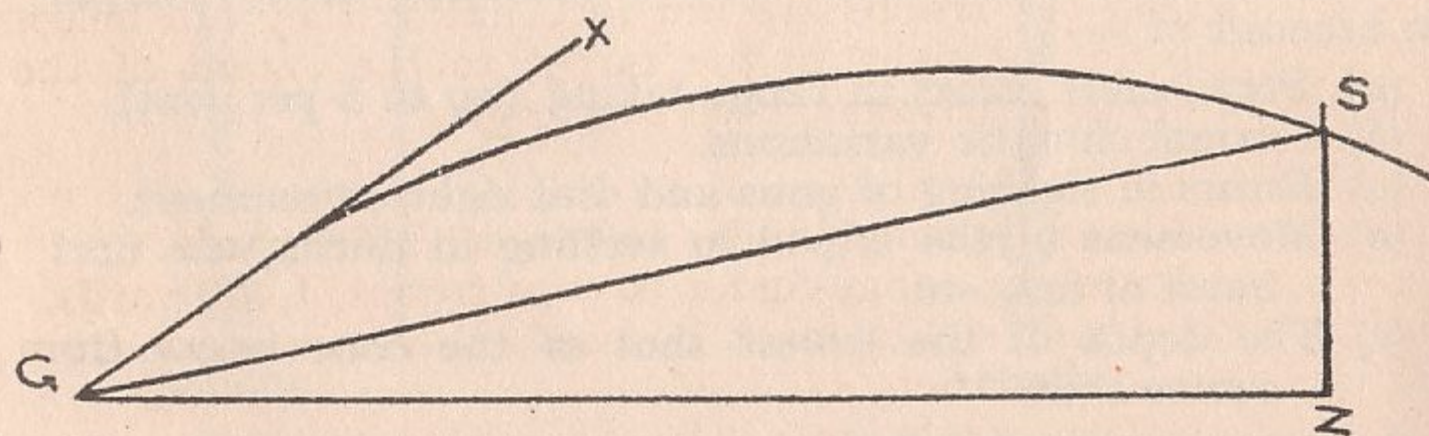


FIG. 46.

Theoretically, there is only one position of the axis of the bore which will cause the centre shot to pass exactly through S. Suppose GX to be this position; any lower position would cause the trajectory to pass below S, and the necessary minimum clearance would not be given.

The angle XGZ is known as the safety angle for the range GZ, and is defined as the minimum angle which must be included between the axis of the bore and the line of sight to our own troops.

It can be easily calculated, as it can be seen that it is made up of the tangent angle for the range to our own troops (XGS) and the amount subtended by the minimum clearance at that range (SGZ). Safety angles are calculated for each range, and are laid down in the range table, pp. 2 and 3.

4. Application of the safety angle.

In order to decide whether our troops in a particular position are safe when a target is to be engaged, it is necessary to compare the safety angle for the range to our own troops with the tangent angle for the range to the target. If combined sights are used, the tangent angle for the lowest range must be compared. The procedure is governed by the following rules:—

- If the safety angle required at the range to our own troops is less than the lowest tangent angle to be employed, our troops are safe.
- If the safety angle required is equal to the tangent angle our troops are safe, provided they are not above the line of sight to the target.

Example:—

If our troops are advancing along the line of sight towards a target the range to which is given as 1,950 yards, fire must be stopped when they reach a point 1,500 yards from the gun, because the tangent angle for 1,900 = $3^{\circ} 47'$ = the safety angle for 1,500 yards. (Range table, page 3.)

- If the safety angle required is greater than the tangent angle, our troops are not safe unless they are below the line of sight to the target to the extent of the difference between these two angles.

Example:—

Range by range-finder to target, 1,700 yards.

Range by range-finder to own troops, 1,400 yards.

Combined sights must be used, therefore work from lowest elevation, i.e. 1,650.

Safety angle re-

quired for 1,400 = $3^{\circ} 23'$ Range table,
Tangent angle for 1,650 = $2^{\circ} 46'$ page 3.

Difference = $37'$

Therefore our troops must be 37' below the line of sight to the target to be safe.

The angle which our troops must be below the line of sight to the target to be safe can be measured from the gun position by means of the graticules in field-glasses, by any other accurate method of measuring vertical angles, or by the slide rule.

ii. In indirect fire, for our troops to be safe, the safety angle for the range to our troops plus or minus the angle of sight to our troops must be equal to or less than the lowest quadrant elevation used to engage the target.

5. Theory of the rules for comparison of the safety angle with the tangent angle.

In Fig. 47, G is the gun, Z our own troops, SZ the minimum clearance for the range GZ and T is the target.

Now if to hit T the axis of the bore were in a position GX and the centre shot passes through S, XGZ, the safety angle, is equal to the tangent angle to hit T, and our own troops are safe.

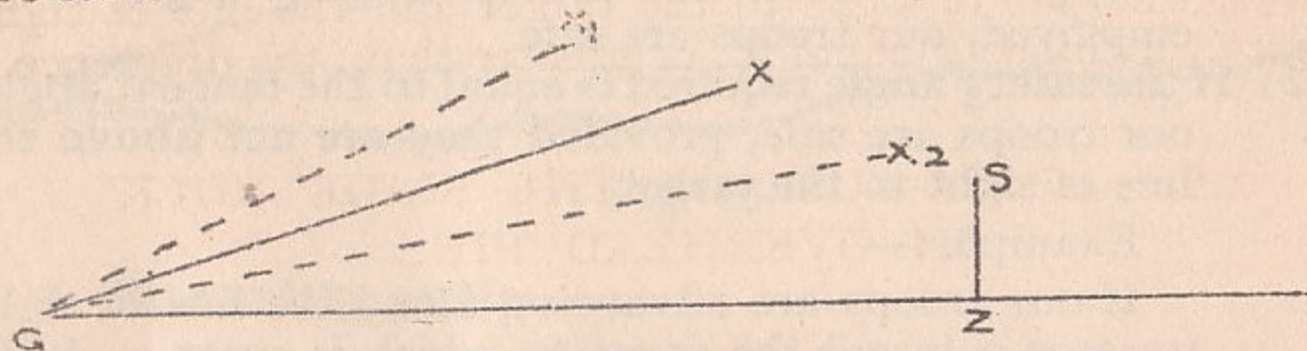


Fig. 47.

If to hit T the position of the axis of the bore were in a position GX₁, the trajectory of the centre shot would pass above S and our troops are safe.

Hence we get the rule that if the safety angle (XGZ) is equal to, or less than, the tangent angle (X₁GT) our troops are safe provided they are not above the line of sight to the target.

If, however, to hit T the position of the axis of the bore were GX₂, the trajectory would pass below S, and our troops at Z are not safe. Here the safety angle (XGZ) is greater than the tangent angle (X₂GT).

We have only considered the case where our troops are on the line of sight to the target. The ground will often be favourable, and our troops (Z) may be below the line GT.

In Fig. 48, the ground is favourable, and our troops, instead of being at Z are at Z₁; we can therefore lower the axis of the bore from GX to GX₁, where X₁GZ₁ is the safety angle for the range GZ₁ (or GZ) and X₁GT is the tangent angle to hit T.

Here it can be seen that the safety angle X₁GZ₁ is greater than the tangent angle (X₁GT) by the amount the ground

has given us (ZGZ₁), and our troops are safe. The ground must give us this amount, or our troops would be unsafe.

Hence we get the rule that if the safety angle for the range to own troops is greater than the lowest tangent angle used

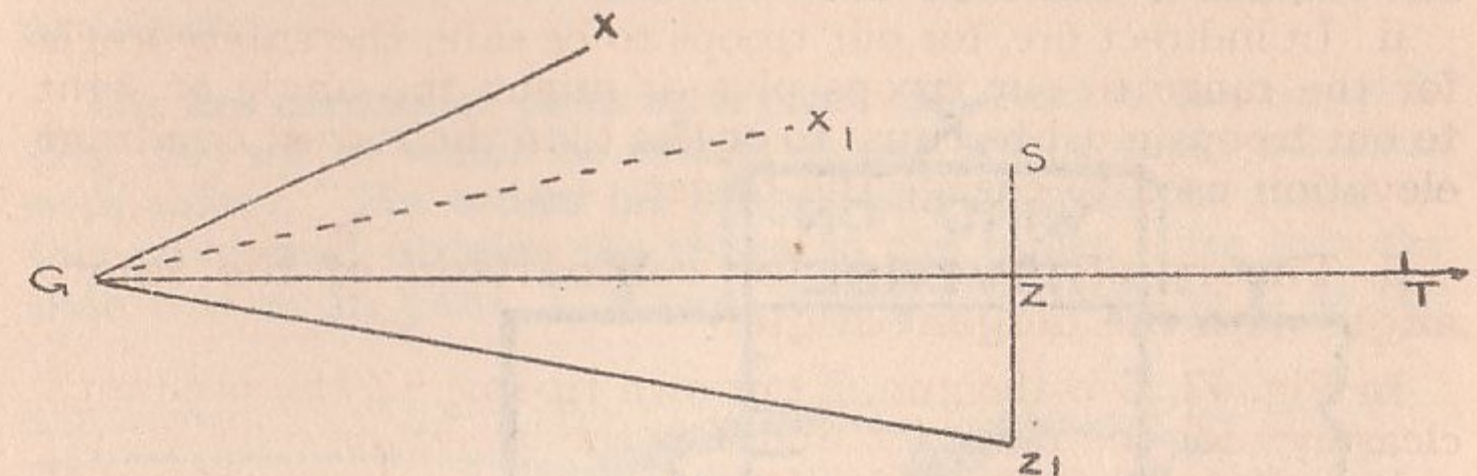


Fig. 48.

to engage the target; our troops will be safe if the angle between the line of sight to the target and the line of sight to our own troops is equal to, or greater than, the difference.

LESSON 127.—USE OF THE SLIDE RULE IN OVERHEAD FIRE

Instructor's Notes

Stores:—

Slide rules and field glasses.

Method of instruction:—

The various methods of applying the slide rule will be explained indoors and the class will then practise on the ground. The instructor setting practical problems.

1. Explain.—The purpose of the slide rule.

In order to save the labour entailed in comparing the tangent angles and safety angles, the Machine-Gunner's Slide Rule is provided. (Lesson 40.)

To use the slide rule in the case mentioned in the example in Lesson 126 4, (c), set 1,400 yards on the "Range to Own Troops" scale against 1,650 yards on the "Range to Target" scale. This will cause the slide to project above the top of the rule.

Hold the rule vertically at the full length of the string, bringing the shoulders at the top of the rule Y, in Fig. 49, along the line of our own troops nearest the target.

If the target can be seen above the top of the slide X our troops are safe.

In effect, the height XY subtends at 24 inches from the eye the amount our troops must be below the line of sight to the target to be safe.

On the right side of the rule will be found a scale on which this amount is indicated when the slide rule is set.

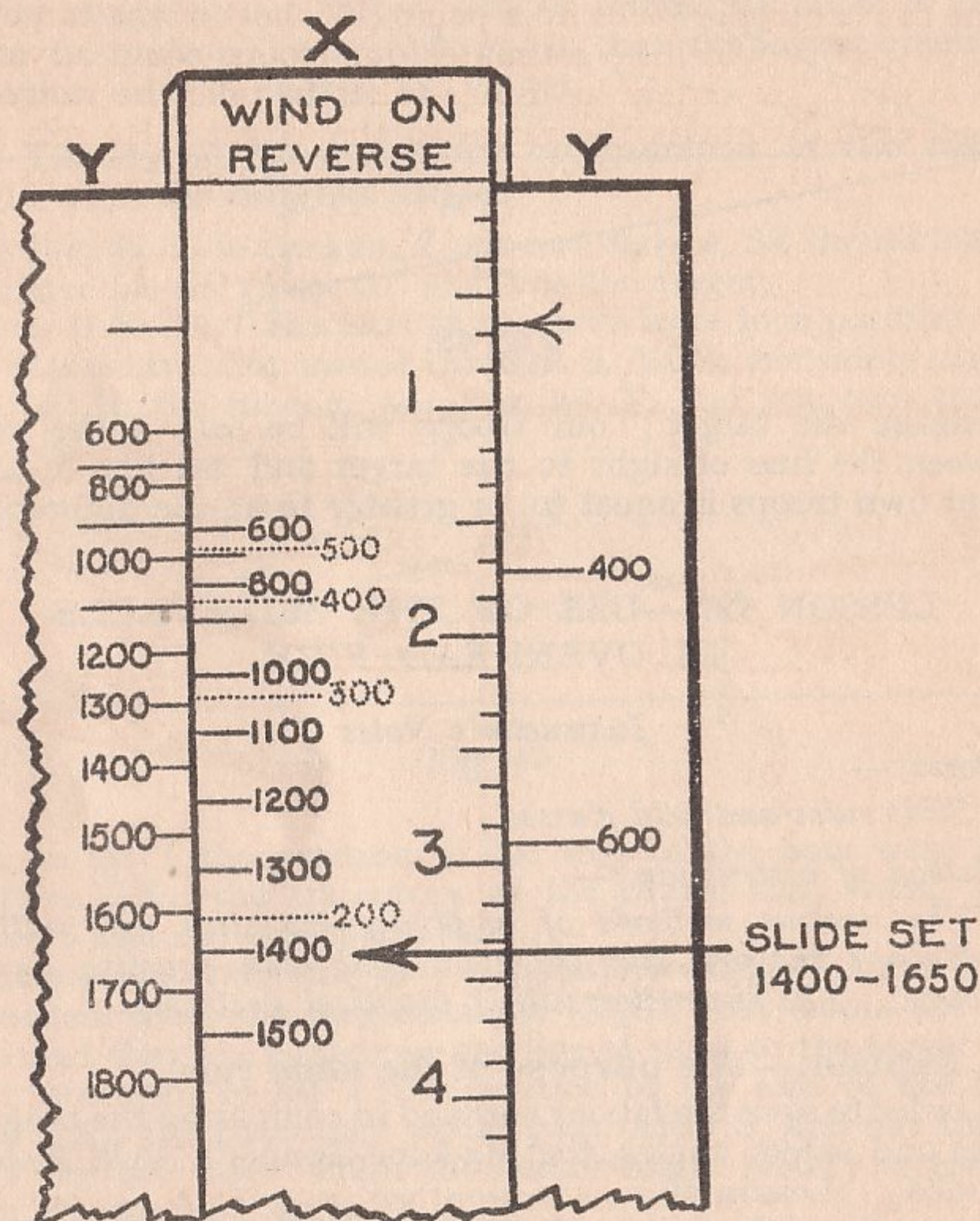


Fig. 49.

2. The practical use of the slide rule.

The slide rule is employed in the following cases :—

i. In the reconnaissance for a position from which to engage a definite target over the heads of our troops who are stationary, to determine whether fire can be opened with safety.

The slide rule is set and used as above.

ii. To determine how near to a target our advancing troops can be supported by overhead fire with safety.

The nearest position of our troops to the target is known as the "far limit of safety" for that particular target.

The problem is solved by trial and error, using the slide rule as follows :—

The fire controller picks up a point (B) short of the target T (Fig. 50) up to which he estimates our troops could advance with safety. He orders his range-taker to take the range to this point and obtains the range to the target. He sets the slide rule as in para. 1, above, taking the range to B as the

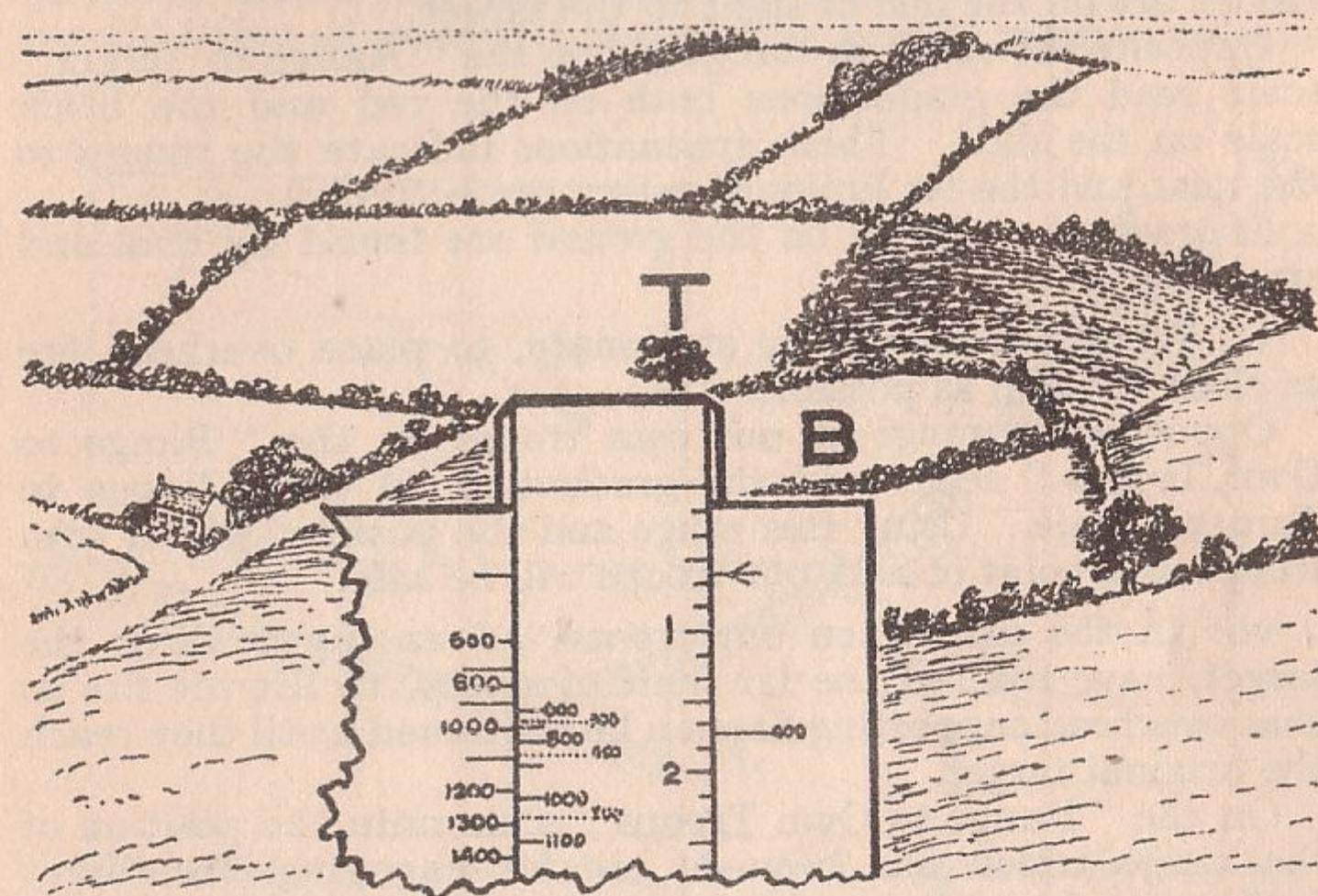


Fig. 50.

range to our own troops. If the projection XY (Fig. 49) does not fit in between the lines of sight to B and T, our fire must cease at some point nearer the gun than B. If it fits in with some amount to spare, then fire can be continued until our troops reach some point closer to T.

Another point is then selected for trial either nearer or further away from B, and the procedure repeated until the far limit of safety is found by a process of elimination.

iii. To determine, when our troops are withdrawing, the line they must clear before fire can be opened on the ground evacuated by them.

Work out the far limit of safety as in ii, above, taking the ground on which fire is eventually required as the target.

iv. To determine, in the case of our troops advancing along the line of fire through the gun line, what line they must clear before fire can be opened.

This position is known as the "near limit of safety" for the particular target concerned.

Using the graduations marked in red on the "Range to Own Troops" scale, proceed as in ii, above.

In the following three cases the slide rule is set with the slide flush with the shoulders at the top of the rule.

v. To determine the near and far limits of safety when our troops are on the line of sight to the target.

Opposite the range to the target on the "Range to Target" scale read the graduations both on the red and the black scale on the slide. These graduations indicate the ranges to the near and the far limits of safety respectively.

The actual positions on the ground are found by trial and error.

vi. When our troops are stationary, to place overhead fire as close to them as possible.

Opposite the range to our own troops on the "Range to Own Troops" scale read the graduation on the "Range to Target" scale. Using this range and the position of our own troops as a point of aim, our troops will be safe.

vii. In the case when our troops, advancing towards the target, have reached the far limit of safety, to lift the fire so that overhead supporting fire can be continued until they reach the original target.

On the "Range to Own Troops" scale note the position of the range which has been in use for engaging the target (this must have been obtained within 5 per cent). Read opposite this the graduation on the "Range to Target" scale. Using this range and the target as a point of aim, our troops will be safe when they reach the position of the target.

LESSON 128.—USE OF AN O.P. IN OVERHEAD FIRE

Instructor's Note

Stores and method of instruction as in Lesson 127.

1. Explain.

i. If our troops and the target cannot be seen from the gun position, e.g. in indirect fire, the rules for the use of the slide

rule must be modified unless an observation post can be found which fulfils the following conditions :—

- It must not be higher than the gun position by more than six feet.
- The target, the gun position and the movements of our own troops along the line of fire in the vicinity of the danger area must be visible.
- The ranges observation post-target and gun-target must be within 50 yards.

ii. The use of an observation post which is not within six feet in height of the gun position in practice presents a complication, and every effort must be made to avoid it by the careful siting of guns and observation post in relation to each other.

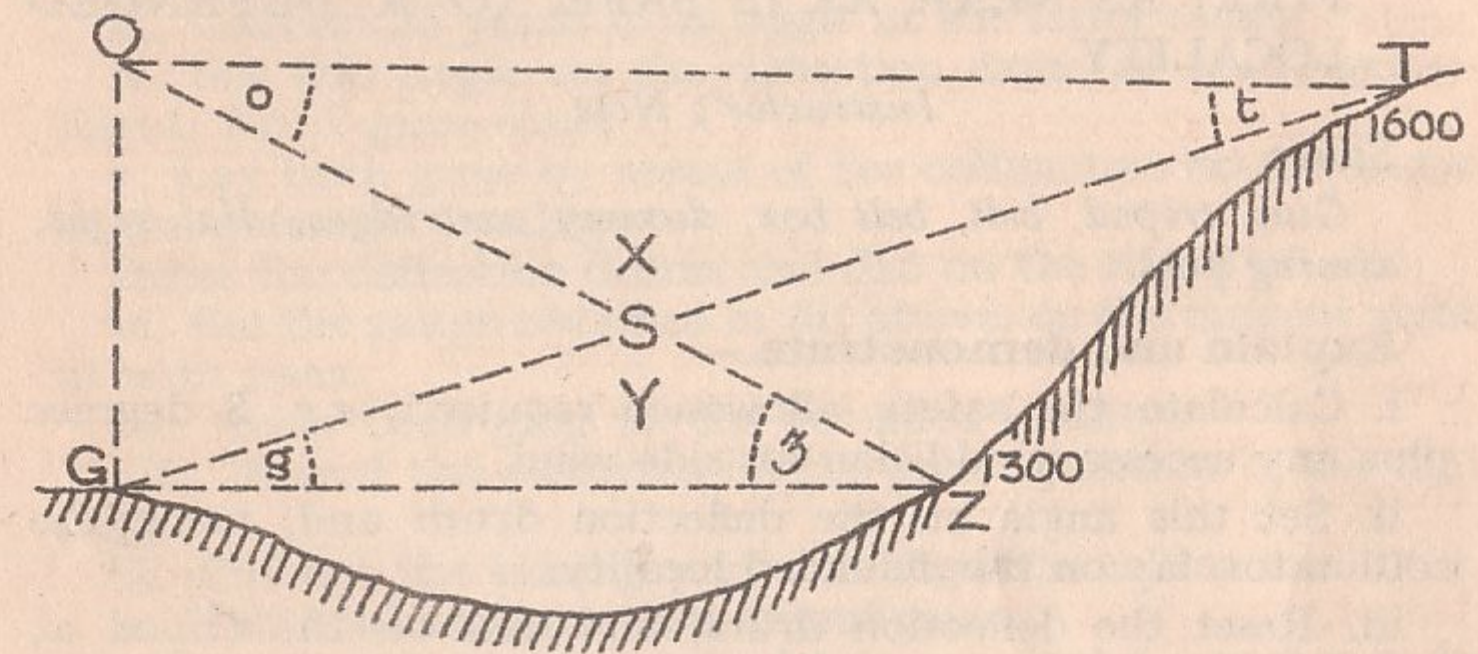


Fig. 51.

When this is unavoidable, the following will be the procedure, which only holds good if the conditions in para. i. (b) and (c), above, are fulfilled :—

- Find the angle subtended by the difference in height between the observation post and the guns at the range to our troops. Subtract from it the angle subtended by this height at the range to the target.
- Set the slide rule in the ordinary way. Using the scale on the right side, increase the amount projecting by the difference obtained in (a), above. Now use the rule in the ordinary way.

iii. Theory.

The sum of the angles of any triangle = 180° . Therefore angles $o + t + X = g + z + Y$.

Angle $X = \text{angle } Y$.

Therefore $o = g + z - t$.

Angle g = normal setting on slide rule.

Angles t and Z can be found by converting the vertical interval GO to an angle, at the ranges $G-T$ and $G-Z$ respectively.

If the height of the observation post above the guns were 10 yards.

Then by V.I. table $t = 21'$ and $z = 26'$.

Difference $5'$.

This is the amount by which the projecting portion of the slide rule has to be increased before using the slide rule.

LESSON 129.—LAYING A FIXED LINE (FLANKING FIRE) AS NEAR AS IS SAFE TO A DEFENDED LOCALITY

Instructor's Note

Stores :—

Gun, tripod, belt, belt box, dummy cartridges, dial sight, aiming post.

Explain and demonstrate.—

i. Calculate the safety allowance required, *e.g.* 3 degrees plus any necessary addition for side wind.

ii. Set this angle on the deflection drum and, using the collimator, lay on the defended locality.

iii. Reset the deflection drum, and dial on the tripod at zero.

iv. By elevating or depressing the gun, pick up the limit of flanking safety.

v. Select a point either on, or outside this line, in the area, where the platoon commander has ordered the fixed line to fall.

vi. Obtain the range to this point.

vii. When this has been done, lay the gun on the selected point with this range on the tangent sight.

The gun is now laid on its fixed line.

viii. Record the elevation now on the gun, by means of the dial sight.

ix. Put out the aiming post and align the collimator on it.

x. Half load and press the thumbpiece.

NOTE.—Both guns of a section will be laid on the same point. Neither gun will tap right nor left.

LESSON 130.—LAYING A FIXED LINE (OVERHEAD FIRE) AS NEAR AS IS SAFE TO A DEFENDED LOCALITY ; EACH GUN COVERING 50 YARDS OF FRONT

Instructor's Note

Stores :—

As for Lesson 129, and in addition, slide rule and range table.

Explain and demonstrate.

i. Obtain the range by range-finder to the defended locality.

ii. From the slide rule or range table ascertain the minimum range which will ensure the safety of the troops in the defended locality.

iii. Convert 25 yards to an angle at the latter range.

iv. Set this angle on the deflection drum of No. 1 gun—Right, No. 2 gun—Left.

v. Lay both guns by means of the collimators on the centre of the defended locality.

Reset the deflection drums and dial on the tripod at zero.

vi. Set the range obtained in (ii) above, on the tangent sight of both guns.

vii. Relay both guns on the defended locality.

viii. Record the elevation on the guns by means of the dial sight.

ix. Put out the aiming post and align the collimators on it

x. Half load and press the thumbpiece.

xi. Determine the number of taps required for each gun to cover 25 yards right and left at the range obtained in (ii), above.

NOTE.—No lifts will be given.

It may be necessary to consider also flanking safety for one or more defended localities.

LESSON 131.—LAYING A FIXED LINE WHEN NO RECONNAISSANCE BY DAY HAS BEEN CARRIED OUT

Instructor's Note

Stores :—

As for Lesson 130, and in addition, torches, aiming lamp.

Explain and demonstrate.

i. A light will be shown in the direction of the guns from a position on which the fixed line is to fall (*see Lesson 92*).

This position must be chosen with due regard to safety.

- ii. (a) Obtain the range by range-finder to the light.
- (b) Lay the gun using the tangent sight set at this range on the light. It may be necessary to assist with a torch.
- (c) Set the range on the range drum of the dial sight and level the bubble by means of the angle of sight drum.
- (d) Set up the night aiming lamp and align the collimator on it.
- (e) Half load and press the thumbpiece as soon as the individual showing the light has cleared the line of fire.

LESSON 132.—SAFETY CALCULATED FROM THE MAP

Instructor's Notes

Stores:—

Maps (1/25,000 or larger scale). Protractors. Range Table.

Method of instruction:—

The instructor will set problems involving both flanking and overhead fire, as explained below.

Explain.

- i. Plot on the map the gun position, the position of our own troops and the target.
- ii. Ascertain from the contours the highest point over which there is a possibility of fire being directed. Subtract from this height the height of the gun position; this gives the height of the crest on which the troops are above the gun position.
- iii. Add to this height the minimum clearance required for the range to our troops. From the Q.A. graph determine whether the trajectory curve for the Q.A. for the target clears this height at the range to our troops.

Example:—

	Range	Contour level
Gun position	—	105 metres.
Target	2,550 yards.	120 "
Own troops	1,000 "	190 "

Target is 15 metres above the gun, therefore Q.A. required is 7° 50'. (Taken from Q.A. graph, using a range of 2,500.)

Our troops are 85 metres above the gun.

The minimum clearance is 18 metres (from Q.A. graph, at bottom) at 1,000 yards.

Therefore total clearance required 103 metres.

The 7° 50' curve gives a clearance of 108 metres at 1,000 yards, therefore our troops are safe.

LESSON 133.—THE TANGENT SIGHT METHOD

Instructor's Notes

Stores:—

Gun, range table, or slide rule.

Method of instruction:—

The instructor will explain the rules for this method and show, by demonstrating with the tangent sight, how the clearance is obtained.

The class will then practise on the ground.

1. Explain.

i. This is a special method of covering advancing troops, only applicable when the ground at the target rises at a considerable angle to the line of sight. It is ineffective on level ground. Its use, therefore, is confined to hilly country, such as is met with in mountain warfare operations.

ii. The principle underlying the method is that after the gun has been laid to hit the target by direct means, the tangent sight slide is raised by an amount depending on the range to the target. The line of sight thus given will indicate the furthest point to which our troops can advance with safety.

iii. The rules for the employment of overhead fire by this method are:—

- (a) The troops over whose heads the fire is being directed must be kept under observation.
- (b) The range to our own troops must not exceed 2,000 yards.
- (c) Barrels and tripods must be in good order.
- (d) The range to the target must be known to within 5 per cent. of error.
- (e) The range to the target must not be less than 700 yards.
- (f) If the range to the target is between 700 and 1,200 yards, the tangent sight slide will be set at 500 yards above the actual range.

If the range to the target is over 1,200 yards, the slide will be set at 400 yards above the actual range.*

2. Procedure.—

i. The fire unit commander, having obtained the range to the target from the range-taker, orders the range or ranges to the guns and indicates the target.

He then orders "Up 500" or "Up 400" as required.

* These rules will give practically the same clearance over our own troops as demanded in range table, pp. 2 and 3. It must be realized that they only apply to troops approaching the target, and not to those in close proximity to the guns.

The firer adjusts the tangent sight slide accordingly and notes where the new line of sight cuts the ground. This point marks the position up to which our own troops may advance with safety, so long as the fire is directed at the target. The firer will use this point as an aiming mark on which to check his aim when firing. Any corrections in elevation to obtain effect will be made by means of the elevating wheel.

ii. When our own troops reach the far limit of safety, the procedure in Lesson 127, may be employed if required.



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